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DEVELOPMENT AND FABRICATION OF A MASS EMISSION DATA AND CONTROL SYSTEM FOR THE STATIONARY SOURCE SIMULATOR

Paul Dimouro, et al

Systems Technology Associates, Incorporated

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16. ABSTRACT

The design for a Mass Emission Data and Control System is presented. An inexpensive minicomputer system is controlling and monitoring operation of wind tunnel experiments for E.P.A. in Raleigh, North Carolina. The multiprogramming capabilities of the disk operating system have been utilized to provide four separate but concurrent system requirements. During full scale operation, the system controls essential wind tunnel parameters, periodically logs up to 27 analog inputs, continually samples 15 sense lines for hazardous conditions and is available for operator command processing. The operator has full control over these functions from the operator's console. Before the experiment begins he defines and characterizes any additional instrumentation connected to the system. He also inputs a time sequence of wind tunnel parameters. At any time during a run, the operator may terminate the experiment, print a time history of logged data in engineering units and shut down the wind tunnel or restart the experiment. This report describes the following: system specifications; technical spedifications; test specifications; system components and software. Flow charts and the accompanying narratives describe the structure and content of the software for the Mass Emissions Data Handling and Control System. A sizable portion of this application was coded in FORTRAN.

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FOREWARD

The efforts described in this report were carried out for the U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, under Contract No. 68-02-0658. The Government Project Officer was Dr. Frederick Jaye of EPA.

The work described in this report was performed between May 1972 and August 1973.

1.0 INTRODUCTION

Systems Technology Associates, Inc. has developed a Mass Emission Data and Control System to provide the primary run-time control and data acquisition functions for a large closed loop wind tunnel. This system is used to simulate the conditions found in smoke stacks of various industries but with carefully controlled conditions. Experiments conducted in the test sections of the "source simulator" can involve sampling, analytical equipment development or testing.

The use of the monitoring, data handling, and control system relieves the operator and experimenter of the routine control and data acquisition functions.

The facility control functions consist of advisory and active control functions. In the advisory mode, certain hazard conditions are monitored and alarms may be initiated. In the control or run mode the computer will attempt to control the simulator directly. The velocity, temperature, and humidity controls of the simulator have "auto" - "manual" switches on the main control panel. In the "auto" position the computer will assume the control duty.

The temperature, velocity and humidity can be programmed to follow a preset time-value curve to simulate cyclic operations. This time value curve is input in the parameter enter mode.

The simulator will repeatedly cycle through this table until instructed to stop. This allows the experimenter to build a statistical base on his experiment.

In the data handling area we have defined two classes of instrumentation: "permanent" and "non-permanent." The permanent equipment is installed on the simulator to measure CO, CO_2, SO_2, NO_X,

H_2O, O_2, temperature, and velocity. These inputs are used for control as well as general data and form the data base as to the actual conditions which exist in the simulator at any given time. The data system will automatically calibrate these instruments and record the data during the experiment.

The system also has facilities for hooking up some 20 additional channels of "non-permanent" instrumentation. These can be almost any types of analog inputs from your experimental equipment. By means of the instrumentation commands you can select which channels should be recorded during the test. A post-test data dump will give you tabulated sheets of these readings versus time.

2.0 SYSTEM SPECIFICATION

2.1 Introduction

The specifications set forth here are going to define the requirements for a Mass Emission Data Handling and Control System. The specification is intended to provide the necessary information required for the design and development of such a system.

The Mass Emission Data Handling and Control System is going to be used for the monitoring of pollutants in smoke stacks and it must have the capability to monitor instrument outputs, and provide the required valve controls and contact monitoring capability. It shall take the instrument readings and convert them to engineering units. Further calculations will result in mass emission values.

EPA instrumentation has been developed which will make all the necessary measurements and the results will be available in an analog form. The data acquisitions from the instrument outputs and their conversion to engineering units and mass emission values, and the automatic control function requirements such as periodic zero and span calibrations of the instruments and the maintenance of an isokinetic sampling condition, timing function and permanent record generation lends itself well suited for the state-of-the-art in minicomputer applications.

2.2 Scope of Work

Systems Technology Associates, Inc. is submitting here a detailed specification which is required for the design and development of the Mass Emission Data Handling and Control System.

2.3 System Functional Definition

The following steps will describe the functional capabilities of the Mass Emission Data Handling and Control System. These functions can be looked upon as modules, which together make up the system as a whole. Basically these functions can be broken down into the following groups.

a. Operator controls
b. Data Acquisition
c. Calibration proceedures
d. Calculation of mass emission rates
e. Logging and record keeping
f. Alarm checking

These groups in a predetermined order on a fixed time schedule should monitor, log and calibrate the pollutant detector instruements. The system to operate twenty-four (24) hours a day, seven days a week.

2.3.1 Operator Controls

Basically there should be thirteen (13) command functions available to the operator which is necessary for proper system control.

2.3.1.1 Load Program

This shall be a hardware function. It will require simple controls to activate the bootstrap loader, and the loading of the program, and the fault limits from the mass storage device into the core memory of the computer.

2.3.1.2 Reset

This command code will cause the resetting of the original fault limits, the abortion of operation in progress and the activation of all the sensors.

2.3.1.3 Set Parameters

This command will allow the operator to set the following operators parameters.

a. Sampling time interval
b. Log time interval
c. Zero calibration interval
d. Span calibration interval
e. Calibration parameters
f. Alarm limits

Sampling Time Interval

The interval period between two (2) sampling cycles shall be entered in minutes not exceeding 60 minutes.

Log Time Interval

There will be two (2) entrys made, one for the normal and the other for the fast log interval. Each will be given in minute , not exceeding 60 minutes.

Calibration Parameters

For each one of the sensors the following parameters are to be entered. The low and high for the zero calibration and also for the span calibration limits and the span calibration gas constant.

The calibration limits shall define the limits which the instruments can fall within without recalibration.

The gas constant is a correction value accounting for the differences in the real value of the calibration gases.

Alarm Limits

There will be two (2) parameters entered here for each one of the mass emission value for the SO_2, NO_x and the particulate pollutants.

The first parameter will be the normal band width of the pollutant level,the second is the maximum rate it is allowed to change. The rate shall in mass emission value change for the particular pollutant per minute.

2.3.1.4 Set Time

This command code will allow the operator to preset the time clock to the year, Julian date,hours and the minutes.

2.3.1.5 EOT and Pause

This command code will cause the mass storage device to terminate recording with an end of transmission code and at the same time all data acquisitions and controls will terminate to allow the operator to change the recorded medium.

2.3.1.6 Pause

The pause command shall terminate all operations.

2.3.1.7 Resume

This command will terminate the EOT and Pause or the Pause State, and the unit will resume normal operation.

2.3.1.8 Deactivate Sensors

In conjunction with this command, the operator shall specify the sensors which the processor should ignore.

2.3.1.9 Force Zero Calibration

This command shall start a normal zero calibration routine.

2.3.1.10 Force Span Calibration

The command shall start a normal span calibration procedure.

2.3.1.11 Force Backpurge

The backpurge command shall cause the activation of the backpurge solenoid for the normal duration.

2.3.1.12 Fast Log

Fast log command will increase the normal sampling cycle rate to the fast logging rate.

2.3.1.13 Normal Log

This command will set the logging rate back to the normal rate.

2.4 Data Acquisition

The processor will initiate periodic instrument reading cycles either at the normal thirty (30) minute or the faster five (5) minute interval if requested by the operator. The particulate sampling reading does require the maintenance of an isokinetical condition.

2.4.1 Particulate Instrument Reading

To maintain the isokinetical condition the equalization of the gas velocity in the instrument with the stack velocity is a must. The following procedure shall be required.

1. Read stack velocity.
2. Read instrument velocity.
3. If readings differ, activate proportional valve control device.
4. Pause.
5. Continue with steps 1 through 4 if the two (2) velocities do not equal.
6. Maintain equalization control for a fixed period.
7. Take reading.

The proportional valve controls digital to analog converter should have at least one part in 256 resolutions.

2.5 Calibration Procedure

Periodic calibration of the instruments are required, due to the drift which is encountered in the monitoring instrumentations. Two (2) types of calibration are required, zero and span calibration.

2.5.1 Zero Calibration

Taking zero calibration readings are necessary to establish a zero reading reference point. The following controls shall be exercised.

1. Activate backpurge solenoid
2. Pause
3. Activate zero solenoid
4. Pause
5. Take readings
6. Deactivate backpurge and zero solenoids
7. Pause

2.5.2 Span Calibration

This calibration procedure is required to establish a reference point with a known value in relation to the zero output level. The sequence given below is required for proper adjustments of the instruments readings.

1. Activate backpurge solenoid
2. Pause
3. Activate calibration valve for the sensor to be read
4. Pause
5. Take reading
6. Deactivate calibration solenoid
7. Repeat steps 3 through 6 for all the required instruments
8. Deactivate backpurge solenoid
9. Pause

The only sensors which do not require span calibration are:

1. Plant output
2. Temperature
3. Stack velocity
4. Instrument velocity

2.6 Calculation of Mass Emission Values

After the conversion of the instrument outputs to engineering units and the correction of these values for the instrument drifts, the processor has to calculate the mass emission rate using the formulas given below.

2.6.1 Dry Volume Flow Rate

$$Q_s = 3600(1-P_w)\ V_sA\left(\frac{T_{STD}}{T_{STACK}}\right)\ \text{ft}^3/\text{hr.}$$

Where P_w = % of water vapor

V_s = Sensed stack velocity in FPS

A = Stack area in ft^2

T_{STACK} = Temperature of stack in $^{\circ}R$

T_{STD} = $530^{\circ}R$ (constant)

2.6.2 Mass Emission Rates in $LB/10^6BTU$

$$SO_2 \text{ emission rate} = \left(\frac{SO_2}{10^6}\right)\left(0.1785Q_s\right)\left(\frac{1}{10^6BTU/hr}\right)LB/10^6BTU$$

$$NO_x \text{ emission rate} = \left(\frac{NO_x}{10^6}\right)\left(0.127Q_s\right)\left(\frac{1}{10^6BTU/hr}\right)\ LB/10^6BTU$$

$$\text{Particulate emission rate} = \left(PART\right)\left(Q_s\right)\left(\frac{1}{10^6BTU/hr}\right)\ LB/10^6BTU$$

Where SO_2 is in PPM

NO_x is in PPM

PART is in PPM

Q_s is in ft^3/hr.

2.6.3 Instrument Output Units

The output of the EPA instruments will be proportional and will be in the following units:

SO_2, O_2, CO, NO_x, N_2, CO_2 and the particulate outputs will be in PPM, as represented by a voltage signal.

H_2O will be in % water vapor as represented by a voltage signal.

Temperature in °R " " " " " "

Vs in Feet/sec. " " " " " "

Plant output in BTU/hr. " " " " " "

2.7 Logging and Record Keeping

All loggings shall be dated with the julian date and the time (hours and minutes). The calculated mass emission rates for the particulate, SO_2, NO_x, and the load factor shall be recorded for each logging operation.

2.7.1 Record Formats

All blocks of recordings to begin with a header record. A block is defined as minimum of one (1) week of recording, but not longer than one (1) calender month, which is terminated with an EOT code. The header record with the recorded format is given below.

This format will allow room for one (1) more value to be inserted within the 72 character record format.

Date/Time	SO_2	NO_x	Particulate	Load
YYDDDHHMM	1.234567	12.34567	123.4567	1234.567

The header as well as the data from one (1) logging operation is to appear as one (1) printed line on the I/O printers hard copy.

Readings out of limits shall be flagged by placing an asterisk (*) after the recorded mass emission value of the particular pollutant, or by placing a colon (:) character in case of a faulty reading caused by equipment failure.

The data is to be stored in the standard ASCII code format in the mass storage device.

2.8 Alarm Checking

The alarm checking function will indicate to the operator by sounding a bell, buzzer or other audible sound for a minimum of fifteen (15) seconds but no longer than thirty (30) seconds, that either one of the following conditions exists:

a. Sudden changes in pollutant levels

b. Mass Emission rates out of limit

c. Equipment failures

d. Span calibration gas depleted

2.8.1 Out of Limit Readings

Sudden changes or mass emission rates out of limits shall indicate an alarm condition to the operator. They are detected when the limits set for them are exceeded. The audible alarm should indicate to the operator that this condition exists. Also, the reasonable interpretation of the situation shall be printed out.

2.8.2 Equipment Failure

2.8.2.1 Plugged Filter

A clear indication of an equipment failure is a plugged filter which cannot be cleared by repeated backpurging. This condition will be indicated by the closure of a normally open switch.

When the processor detects this condition, an automatic activation of the backpurge solenoid should take place. This should be repeated five (5) times if necessary. If the condition still exists the operator shall be notified by sounding the audible alarm, and also by printing out the fact that the filter is plugged.

If the switch closure occurs during a data acquisition or a zero or span calibration procedure, the entire sequence shall be terminated and all readings nullified. The whole sequence to be repeated after the plugged filter condition has been rectified.

2.8.2.2 Failure to Attain the Equalization of the Two Velocities

The condition where the velocity of the gases in the instrument cannot be equalized with the stack velocity shall indicate an equipment failure. The audible alarm should be sounded and the appropriate information to be printed out; normal operation to continue until operator's intervention.

2.8.2.3 Instrument (s) Out of Calibration Range

This can indicate two (2) problems, but in either case, a manual intervention is required.

a. Equipment has broken down and does not respond to calibration procedures.

b. Sensor instrument is out of allowable calibration limits and requires manual intervention.

2.8.2.4 Span calibration gas depleted

The low level of the available calibration gas shall be indicated by the closure of a normally open contact. The operator shall be notified by sounding the audible alarm and also by a printout for hard copy monitoring.

2.8.3 Alarm Condition Indicators

Besides sounding an audible alarm, a reasonable interpretation is required of the alarm condition. This can be printed out on the I/C printer. All printout shall be in plain English. However, for the permanent record keeping, it is required only that the particular pollutant value be flagged by one (1) asterisk (*) for values out of limit or sudden changes in pollutant levels. Faulty readings due to equipment failure shall be flagged with a colon (:).

3.0 TECHNICAL SPECIFICATIONS

3.1 Input/Output Specifications

The system shall accept the following inputs and provide the outputs to this specification. The maximum distance from source to termination will not exceed 25 feet.

3.1.1 Inputs

The system shall have the capability to monitor and accept data from the following sources.

3.1.2 Instrument Outputs

Type:	Analog unipolar with guard
Number of inputs:	Maximum of sixteen (16)
Input range:	0V to 1.0V full scale
Source impedance:	100 ohms maximum (Balanced)
Type of cable:	twisted pair from each instrument

3.1.3 Contact Closure

Type:	Normally open, snap action
Type of cable:	twisted pair, one from the common, the other from the normally open contact
Contact ratings:	115V @ 1 amp and 5.0V at 10 ma. non-inductive
Contact resistant:	0.05 ohms maximum
Number of contacts:	Two (2)

3.2 Outputs

The system shall generate signals to drive and control the following devices.

3.2.1 Proportional Valve Control Signal

Type:	Analog, Unipolar with guard
Output range:	0V to +5.0V @ 10 ma. (Balanced)
Maximum output loading:	1K ohms parallel with a 1000pf capacitor
Number of drivers Required:	One (1)

3.2.2 Solenoid Driver

Type of control:	on/off type
Load:	230VAC @ 1 amp or 115VAC @ 2 amp Non-inductive.
Number of drivers Required:	Sixteen (16)

3.3 Computer

A state-of-the-art mini computer shall have the capability to accomplish all the data acquisitions, solenoid valve controls, periodical zero and span calibrations, proportional valve control to maintain isokinetical sampling of the particulate pollutants, permanent records, etc. as defined by the Functional Specifications (2.0).

It also must fulfill the following minimum requirements:

3.3.1 Hardware

Word size:	Twelve (12) bits min.
Memory size:	8K min.
Program loading:	Bootstrapping capability
Power Fail and Auto restart:	Yes
Programmable real time clock:	Yes
Optional plug in module:	Communications modem interface

3.3.2 Software

All operators dialog to be either in English or in simple mnemonics.

The command code to be structured in such a way that spaces or particular terminators are not critical.

3.3.3 Enclosure

The computer is to be housed in an enclosure in such a way that it will provide protection from dust, vibration and from dripping water, however, meeting military specifications is not required. The unit will require dry instrument air for positive purging.

The computer is to have such minimum environmental specification, so when it is mounted in the enclosure it will function in the following environment.

Ambience temperature outside of the enclosure:	+50°F to 100°F
Relative Humidity:	20% to 90% without condensation

3.4 Peripherals

3.4.1 Mass Storage Device

The mass storage device is to be selected in a way that when it is connected to the processor the system is still going to meet minimum requirements set forth in Functional Specifications (2.0).

It also shall have the following specific requirements:

Character code:	ANSCII
Character size:	7 bit plus parity
Record size:	72 characters

Type of operation:	Remote, with simple operating procedure not requiring much operator's skill and attention.
Interface to processor:	Bi-directional. (Read and write mode)

The mass storage device shall be mounted either with the processor, in which case it must meet the environmental requirements of the processor, or with the I/O printer device, in which case it will be located 500 feet away from the processor and has to meet the same environmental requirements as of the I/O printer.

3.4.2 Input/Output Printer

This device is to serve a double purpose:

a. To provide an operator-computer communications
b. To provide hard copy readout of the date, time (hours and minutes) and recorded pollutant concentrations.

It should meet the following requirements:

Keyboard:	Similar to office type keyboard. 4 row, 8 level
Speed:	10 character/second minimum
Maintenance interval:	Not less than every six (6) months.
Distance from computer:	500 feet maximum
Environment:	40°F to 100°F R.H. 20% to 90% without condensation.

3.5 System Power Requirement

The system must have the capability to accommodate various voltage input ranges.

Also, the system must function with large voltage fluctuations. A line voltage stabilizer capability is a must.

The system must be able to operate with only one of the following power inputs:

115VAC ±15%	single phase 60 cycle ±0.45 cycle
205VAC ±15%	single phase 60 cycle ±0.45 cycle
230VAC ±15%	single phase 60 cycle ±0.45 cycle
440VAC ±15%	single phase 60 cycle ±0.45 cycle

However, it is required only that any given system is to operate either with 115/205/230 VAC or 230/440 VAC inputs. One of the two (2) groups of power inputs will be specified when ordering the system.

3.6 Power Wiring and System Cabling

All internal power wiring is to be supplied with the system. From the voltage regulator device to the processor and to all of the peripheral devices.

A clearly marked terminal strip with Ground, the neutral and the appropriate voltage inputs should be supplied for the external connection of the power line.

All the signal cablings are also to be supplied internal to the system, from the processor to all of the peripherals and other devices requiring electrical signal connections.

A terminal strip clearly marked shall be provided for external connection of all the sensors, solenoids, valve control and contact closure devices. Each of the terminals on the strip shall be assigned physically to one of the devices mentioned above.

4.0 TEST SPECIFICATION

The fabricated Mass Emission Data Handling and Control System shall be tested in a laboratory environment in such a way that the test will result in a reasonable proof that the system also going to perform to specifications in an actual working environment. The limitation of the test is that no dynamic feedback loop exists for the proportional valve control function.

4.1 Tester

To accomplish the testing properly, a tester which will simulate all of the sensing instruments, valves, solenoids and contact closures are required. All of the simulators shall be labeled with the device names they are representing.

4.1.1 Instrument simulators (Inputs)

To simulate the analog input, a variable analog source is required with either an indicator with an adjustment, or a marked dial for easy reading and adjustment of the analog input values.

4.1.2 Contact Closer (Input)

To simulate the plugged filter condition, a toggle switch for the input is satisfactory.

4.1.3 Proportional Valve (Output)

The changes in the analog output level shall be monitored by a visible indicator device. (Voltmeter)

4.1.4 Solenoid Valve Controls (Outputs)

A visible indicator shall show the solenoid valve(s) which had been activated. (Lamp)

4.2 Modular Testing

The testing to take place in a modular form. Unique functions to be tested as independent modules. The following systems capabilities shall be demonstrated:

a. Powering up procedure, including the loading of the program from the mass storage device.

b. System initiation procedure, entering the operators parameters and presetting the date and time.

c. Demonstrate all of the demand functions. Zero calibrate, span calibrate and backpurge.

d. Demonstrate out of limit calibration alarm conditions by setting the analog input so the zero and then the span calibration will be out of range.

e. Demonstrate normal logging operation.

f. Show alarm condition, when the two (2) velocities cannot be equalized.

g. Demonstrate all of the operators controls. Pause, EOT & Pause, resume, fast log, normal log, reinitialize, deactivate sensors.

h. Demonstrate data acquisition and logging functions. During the normal operation cause out of limit readings, out of limit calibration and the failure of equalizing the two (2) velocities.

i. Print out from the mass storage device the accumulated data acquired during the data acquisition demonstration.

5.0 SYSTEM, SYSTEM COMPONENTS AND SOFTWARE APPROACHES

STA has completed a thorough investigation of the mini-computers, peripherals, interface modules and software approaches, keeping in mind the criterion set forth by the Environmental Protection Agency.

5.1 Hardware Evaluation

Hardware evaluations were based on the following qualifications:

a. Functional and environmental qualifications best suited for the job.
b. Cost/Performance trade-offs
c. Software trade offs affecting hardware selections.

STA has evaluated many more devices than we are presenting here, but we feel that the ones we have selected could best meet the overall system performance and the systems cost criterion.

5.1.1 Computer Evaluation

The following three (3) mini-computers have been selected for the consideration of the Environmental Protection Agency:

a. Digital Computer Corporation: D-116
b. Texas Instrument: TI960A
c. Digital Equipment Corporation: PDP-8/E

The selection of these three (3) units was based on the considerations listed below:

a. Performance to match the technical requirements of the job.
b. Cost
c. Past experience with the device.

d. Product support and service.
e. Availability of off-the-shelf interfaces required for the job.
f. Software availability.
g. Reliability

5.1.1.1 The two (2) charts given below are for a quick comparison of the three (3) processors for their hardware and software qualities and cost trade offs.

COMPUTER EVALUATION CHART

	TI 960A	DCC-116	PDP-8F
HARDWARE			
Variable device bootstrap loader	no	yes	no
Power Fail & Auto Restart	yes	yes	yes
Real Time Clock	yes	yes	yes
Input/Output Module	yes	no*	no*
D/A Converter Module	yes	no*	no*
A/D Converter Module	no*	no*	no*
EIA RS-232 Interface	yes	yes	yes
TTY ASR-33 Interface	yes	yes	Standard
SOFTWARE			
Floating Point Software			
1. ASCII to floating	yes	yes	yes
2. Floating Add	yes	yes	yes
3. Floating Subtract	yes	yes	yes
4. Floating multiply	yes (no error detect)	yes	yes
5. Floating divide	yes (no error detect)	yes	yes
6. Floating to ASCII			
a. "E" Format	yes	yes	yes
b. "F" Format	no	yes	yes
Character representation	2/word	2/word	1/word
Instruction word	32 bits (2 word)	16 bits	12 bits
Floating point word	32 bits (2 word)	32 bits (2 word)	36 bits (3 word)
Run time debug	no	yes	yes
Disk Operating System	yes	yes	yes

Note: * Requires custome designed interface.

SYSTEMS HARDWARE COST BREAKDOWN

	D-116	TI960A	PDP-8/E
Central Processor	$ 5,040.00 (w/8K mem)	$ 4,350.00 (w/8K mem)	$ 6,840.00 (w/12K mem)
Power Fail/Auto Restart	320.00	100.00	250.00
Bootstrap Loader	160.00	250.00	500.00
Real Time Clock	320.00	200.00	300.00
TTY ASR-33	900.00	1,500.00 (w/interface)	900.00
D/A Converter Module		450.00	
Input/Output Module (Relay Driver)		600.00	
Interrupt Module		150.00	
TTY Interface	290.00		Standard
±15 V Regulator		200.00	
I/O Expander		300.00	
	$ 7,130.00	$ 8,100.00	$ 8,790.00
Cables, cabinet, misc.	1,500.00	1,500.00	1,500.00
Parts for the A/D, D/A and Input/Output Modules	2,480.00	700.00	2,480.00
	$11,110.00	$10,300.00	$12,770.00
Cassette Recorder (Techtran)	1,870.00	1,870.00	1,870.00
Cassette Interface EIA RS232	370.00	350.00	425.00
	$13,350.00	$12,520.00	$15,060.00
Fortran (added cost of memory)	3,280.00	3,000.00	920.00
Total Cost	$16,630.00	$15,520.00	$15,980.00

Note:

1. All prices are from manufacturers catalog.
2. 20% anticipated discount is included in the pricing of the D-116 and PDP-8/E.
3. No OEM discount for the TI960A.

5.1.1.2 Conclusion

From the available information, the following conclusions can be drawn:

1. The lowest cost system is the Texas Instrument Model 960A with it's $ 12,520 price tag. It requires the design of the A/D converter only.
2. Because of the low speed of the application, any speed comparison is needless.
3. Memory parity is standard with the TI 960A, while it is not available on the D-116 and it is a $3,000.00 option for the PDP-8, but this may not be a significant consideration.
4. The most proven device is the PDP-8E with the D-116 a close second. The D-116 is a copy of the Nova-1220 processor and it is using the same software. Most of the hardware is interchangeable. Improvements have been made on such things as the power supply, which has been a weak link in the Nova 1220 processor. The TI 960A processor has not been on the market much more than six months, but it had a 2 year test bed in Dallas, Texas as the Model 960 and has a calculated MTBF of 4,000 hours. Also, while the TI 960A is a new physical configuration mini-computer, the company behind it is well established.
5. We have had good experience with both D-116 (through the Nova) and the PDP-8E. We have had no experience with the TI 960A.
6. Software trade offs are a little bit more difficult to evaluate. The PDP-8E perhaps has the best software with the D-116 a close second.
7. Fortran programming is available with all of the processors; however, for the PDP-8E a high speed paper tape reader and punch would be required.

5.1.2 Mass Storage Device

The following systems requirements will affect the selection of a mass storage device:

5.1.2 continued

a. Inexpensive, remote mass storage device requiring little attention and service.
b. Automatic loading and reloading of the program into the memory of the computer with minimum operators skill.
c. To provide optional communication capability (EIA 232-B type).
d. To be able to store minimum of one (1) week's data with a worst case of three (3) days of logging at the faster (5 minutes) rate and four (4) days at the normal thirty minute interval.
e. Reliability.

5.1.2.1 Cassette Recorder

All the above requirements can be met with a properly selected cassette recorder. We suggest a single cassette recorder, with a dual recorder available as an option.

The following cassette recorders have been evaluated:

a. Sykes Model 2220
b. Remex Model RCPOB11/1
c. Techtran Model 4130
d. Cipher Model C-2000-1

The following chart indicates the trade-offs of the above mentioned devices:

	SYKES MODEL 2220	CIPHER MODEL C-2000-[1]	REMEX MODEL RCPOB11/[1]	TECHTRAN MODEL 4130
Price	\$2,900.00 (w.EIA 232)	\$2,100.00	\$1,870.00	\$1,890.00 (w.EIA 232)
Number of Tracks	1	2	2	1
Recording Method	800 or 1000 BPI Phase encoded	800 BPI Phase encoded	800 BPI Phase encoded	800 BPI Phase encoded
Charac. Length	7 bit plus parity	7 bit plus parity	7 bit plus parity	7 bit plus parity
Record Length	Variable	Variable	Variable	100 character (fixed)
Error Rate	1 in 10^8 bit	---	1 in 10^8 bit	1 in 10^7 bit
Write Check	None	Read after Write stand.	Redundant dual track record.	None
Read Check	Character Parity	Char. Parity LRC, Check sum.	Character Parity	Character Parity
Tape Capacity (300 ft. reel)	720,000	360,000	250,000	70,000
EIA Communcation Interface	yes	no	\$595	Standard
PDP-8E Interface	no	yes (\$829.00)	\$750	no
D-116 Interface	no	yes (744.00)	\$750	no
Texas Instru. 9[illegible]0A	no	no	no	no
Environment	4°C to 45°C R.H. 20% to 95%	2°C to 50°C R.H. 0% to 90%	5°C to 40°C R.H. 5% to 95%	5°C to 45°C R.H. 20% to 90%
Dual Cassette	Standard	yes (\$900)	Yes (\$630)	No

CASSETTE RECORDERS EVALUATION CHART

Note:

All prices are from manufacturers catalog and OEM discount is included where appropriate.

5.1.2.2 Conclusion

The final decision where the cassette recorder will be located will greatly influence the final selection. The recording medium won't allow a wider temperature limit than 50°F to 90°F without suffering degradation of its reliability. This fact may make it not possible to mount the cassette recorder with the processor. In this case the transmission will have to take place over a 500 ft. cable. The mechanisms have been designed especially for digital application. We have drawn the following conclusions:

a. Continual integration of the data can be maintained reasonably well with any of the four cassette recorders. The Cipher Model with its read-after-write capability may be attractive. However, the dual track redundant recording method of the Remex Model RCPOB11/1 also offers similar features. It is yet to be proven that any of the above is required.
b. Availability of interfaces for the four models are almost the same. Cipher is the only one not having an EIA interface. None of them has a direct interface to the TI960A. The EIA 232-B type interface is universal. It would require, however, to drive the 500 foot distance.
c. Software required with the EIA 232 interface is the same as used with the papertape reader/punch.
d. Cost-wise the Cipher is the most expensive and the Sykes the second. Techtran is the least expensive.
e. Tape Capacity. Sykes cassette could hold up to one month's recordings, while the others would be more than sufficient for one week's recording.
f. Communications modems interface; the best suited device for this purpose is the Sykes model. This device can be used in the following way:

CPU ⟷ Cassette
CPU ⟷ Modem
Cassette ⟷ Modem

STA feels that the best cost/performance trade-offs are provided by the Techtran cassette recorder.

5.1.3 Console Terminal

We recommend the Teletype Corporation ASR-33 Teleprinter. It is a reliable, inexpensive I/O printer which has the capability to send and receive with a maximum cable length of 1000 feet. To decrease the maintenance interval of 500 operating hours, we are going to equip it with an Automatic Motor Start device. Prior to the start of a printing cycle, a short pulse from the CPU will activate the device. The power is going to be supplied from the system power distribution network. This will allow the ASR-33 to run with the following input power to the system: 95 to 130VAC, 175-235VAC and 190-260VAC, 60 Hz.

5.1.3.1 Technical Specifications

(See following page)

5.1.3.1 Technical specifications

Speed	Characters Per Second	6	6.6	7.5	10
	Words Per Minute	60	66	75	100
	Bauds	66.0	74.0	82.5	110

Code	8-level, 11 unit basis (ASCII)
Tape	8-level, 1 inch wide oiled paper
Printer	Friction feed platen for 8-1/2 in. single or multiple ply paper Horizontal spacing 10 characters per inch (12 characters optional) Vertical spacing single or double row (3 or 6 lines per in.)
Keyboard	4-row, 8 level. Similar to typewriter
Temperature	Operating: 40°-110°F ambient; humidity: 95% maximum.
Power Requirements	115 V AC ± 10%, 60 Hz ± 0.45 Hz, single phase synchronous motor 50 Hz motor also available. approx. input current: starting 8 amps running 2 amps approx. wattage: RO - 95 watts KSR - 95 watts ASR - 110 watts
Maintenance Interval	Once every six months of after 500 operating hours, whichever occurs first.

5.1.4 Communications Module

We recommend for future option, a standard EIA RS232 type module. With this module via a Modem the system would have a communications capability.

5.1.5 Line Voltage Stabilizer

Due to the environment where large voltage fluctuations can occur, a need is present for a line voltage stabilizer. Also, the various voltage inputs must be accomodated.

5.1.5.1 The Sola Constant Voltage transformer CVS model type should satisfy both requirements. This device also will control the harmonics to less than 3% RMS. By specifying the voltage inputs when ordering one of the two 1KVA CVS transformers can be supplied; one with an input range of 95V-130V, 175V-235V and 190V-260V. The other has an input voltage range of 190V to 260V and 380V to 520V. Both of them take 60 Hz single phase input.

5.1.6 Input/Output Module

This module is going to be a sixteen (16) solenoid driver and sixteen (16) contact closure monitor if the Texas Instrument Model 960A is going to be selected. We recommend their standard Input/Output module which is readily available. If the PDP-8E or the D-116 computer is selected, STA will design the Input/Output module. We feel that twelve (12) solenoid drivers and two contact closure monitor should be sufficient.

5.1.6.1 The Solenoid Driver

The output stage of the solenoid driver will be a normally open switch contact with a rating of 230VAC @ 1 amp non-inductive load.

5.1.6.2 The Contact Monitor

This device will monitor and detect when the normally open switch has closed.

5.1.7 Analog Input Module

STA has decided to design this module to suite the special application of the Mass Emission Data Handling and Control System. We suggest to use all Analogic Corporation components.

5.1.7.1 Multiplexer AN 4716

This device is a sixteen (16) channel multiplexer. It will switch sixteen (16) single ended channels one at a time. It will provide high transfer accuracy with a break-before-make channel switching which minimizes inter-channel interference. It also provides input current limiting during both power "on" or "off".

"Off" impedance	2KM ohms
"on" resistance	1180 ohms max.
Off channel leakage	50nA @ 23°C
Current limiting	680 ohms plus switch resistance of 500 ohms
Transfer accuracy	0.01% F.S. @ 1 KHz and @ 1 K ohms source impedance
Operating temperature	0°C to 70°C

5.1.7.2 Analog to Digital Converter, AN 2344

This device has an excellent 60 Hz rejection capability. Being an integrating device it uses the data averaging method which eliminates noise interference. The integration period can be made of the multiples of 60 cycle to remove the major offender, the power line. A 100 msec. input integration will provide the best rejection of 50/60 cycle interference.

Accuracy	0.01% @ 23°C
Stability	0.5mV/°C maximum
Common mode ref.	100 dB at 50 or 60 Hz w/1K ohms source imbalance.
Operating temperature	-10°C to 60°C

5.1.8 Digital to Analog Converter Module

With the TI960A we recommend their standard D/A converter module. For the D-116 and the PDP-8/E, STA would design the D/A module using an Analogic AN1808M device. This device will provide a 1 part in 256 resolution. It was designed for industrial applications and it has a high stability and linearity with an outstanding long term temperature stability. The output is short circuit proof to ground. The output can be changed by moving the jumper wire from

± 10V @ 10ma
± 5V @ 10
0V to 5.0V @ 10ma

The maximum output loading is 1K ohms parallel with a 1000 pf. capacitor. Conversion accuracy = ± 0.1% F.S.R. maximum

5.2 Software Description

5.2.1 General

The following flow charts and accompanying narratives describe the structure and content of the software for the Mass

Emission Data Handling and Control System. The software has a highly modular structure which enables the user to easily drop and add functions. The system operates in states to the extent that the system is set into a given state by a command, timed event or alarm condition and remains in that state until the required sequence of operations is completed or is overridden by a condition which sets a higher priority state.

The system essentially operates at one background level with short interrupt routines serving merely to set flags or pass data strings. The ring input/output technique is used to minimize processing delays caused by slow input/output operations.

The system operates under control of the executive which interprets operator commands and entries and sets the appropriate state. The module for each state then determines which tasks are required and sequences accordingly. The system may enter one of ten states each of which is described in the following sections:

a. Pause
b. Wait
c. Idle
d. Reset
e. Parameter
f. Back Purge
g. Zero Calibration
h. Span Calibration
i. Sample
j. Log

5.2.2 Executive

The executive module contains three primary elements plus additional state determination logic to determine the state which is to be entered.

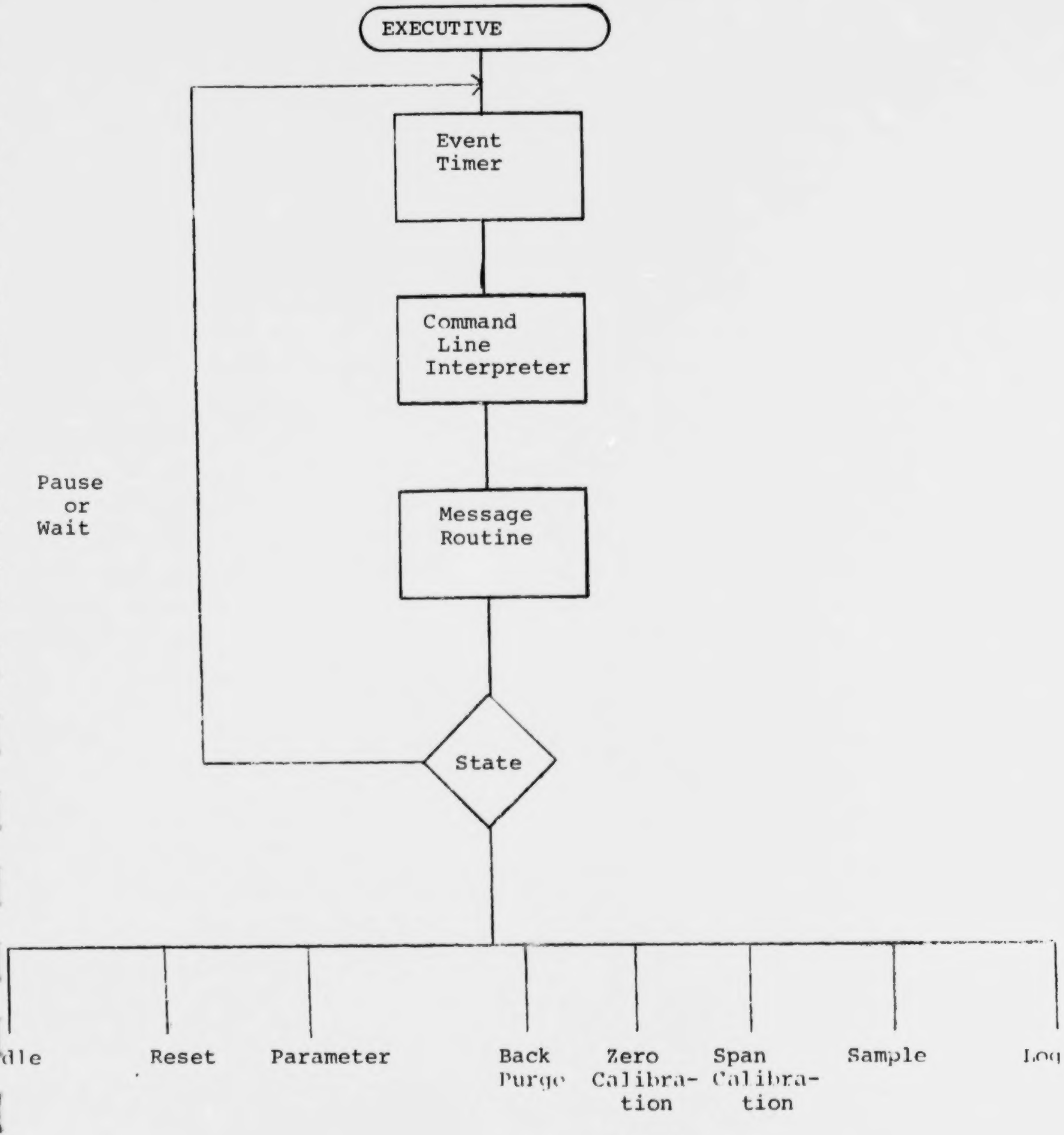

EXECUTIVE
Event Timer
Command Line Interpreter
Message Routine
Pause or Wait
State
Idle
Reset
Parameter
Back Purge
Zero Calibration
Span Calibration
Sample
Log

Figure 5.2-2. EXECUTIVE

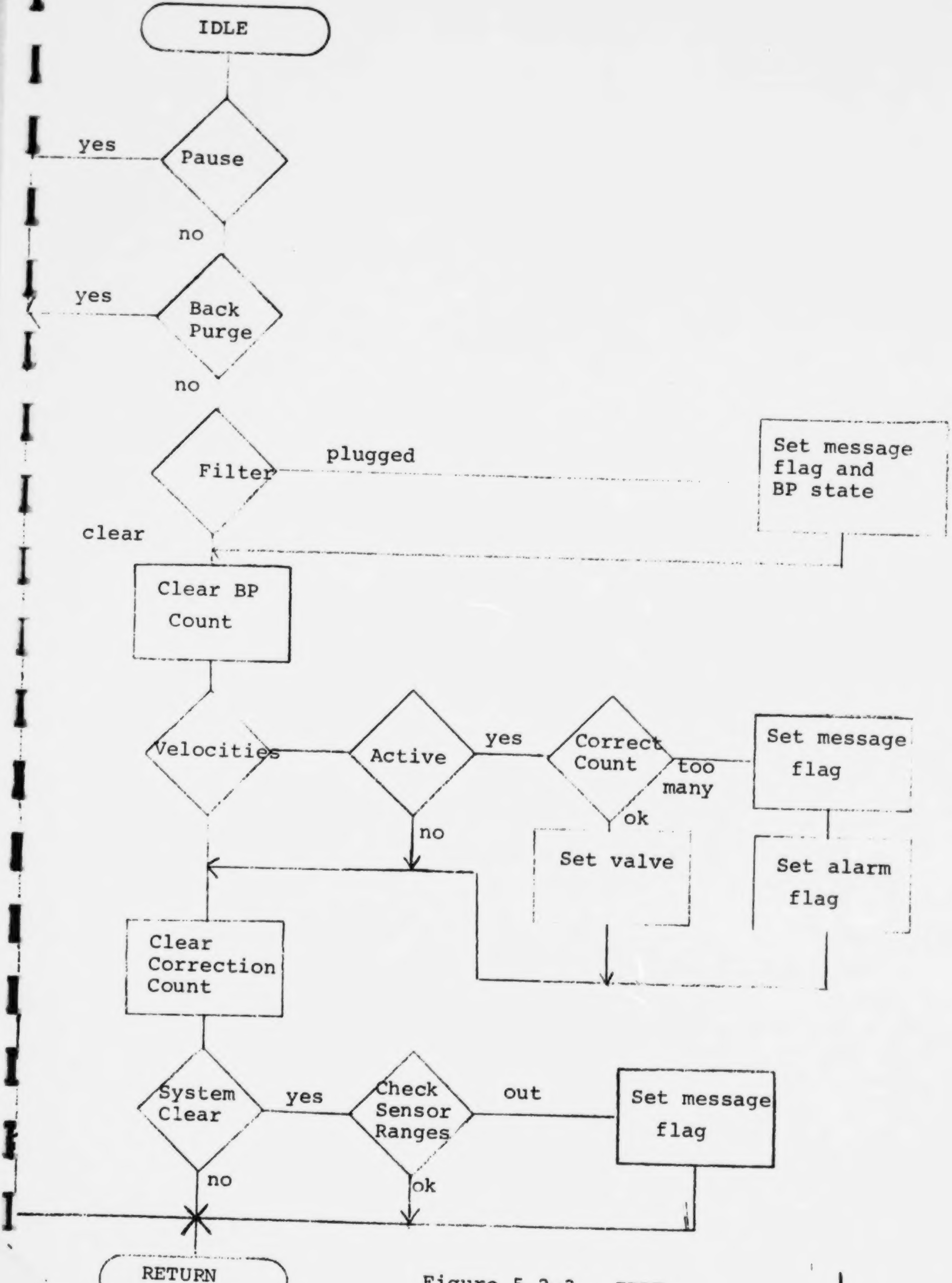

IDLE
Pause
yes
no
Back Purge
yes
no
Filter
plugged
Set message flag and BP state
clear
Clear BP Count
Velocities
Active
yes
no
Correct Count
too many
ok
Set message flag
Set valve
Set alarm flag
Clear Correction Count
System Clear
yes
no
Check Sensor Ranges
out
ok
Set message flag
RETURN

Figure 5.2-3. IDLE

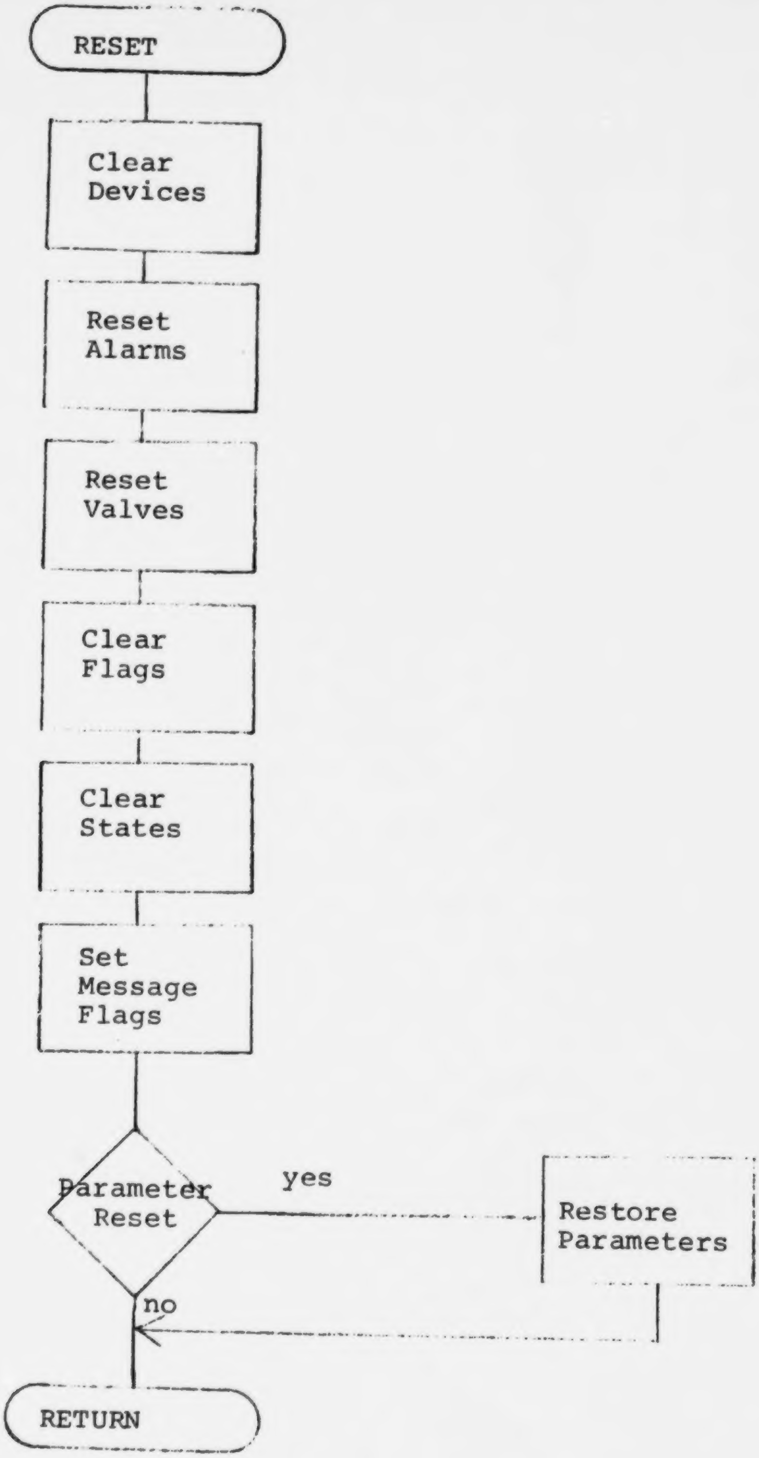

RESET
Clear Devices
Reset Alarms
Reset Valves
Clear Flags
Clear States
Set Message Flags
Parameter Reset
yes
Restore Parameters
no
RETURN

Figure 5.2-4. RESET

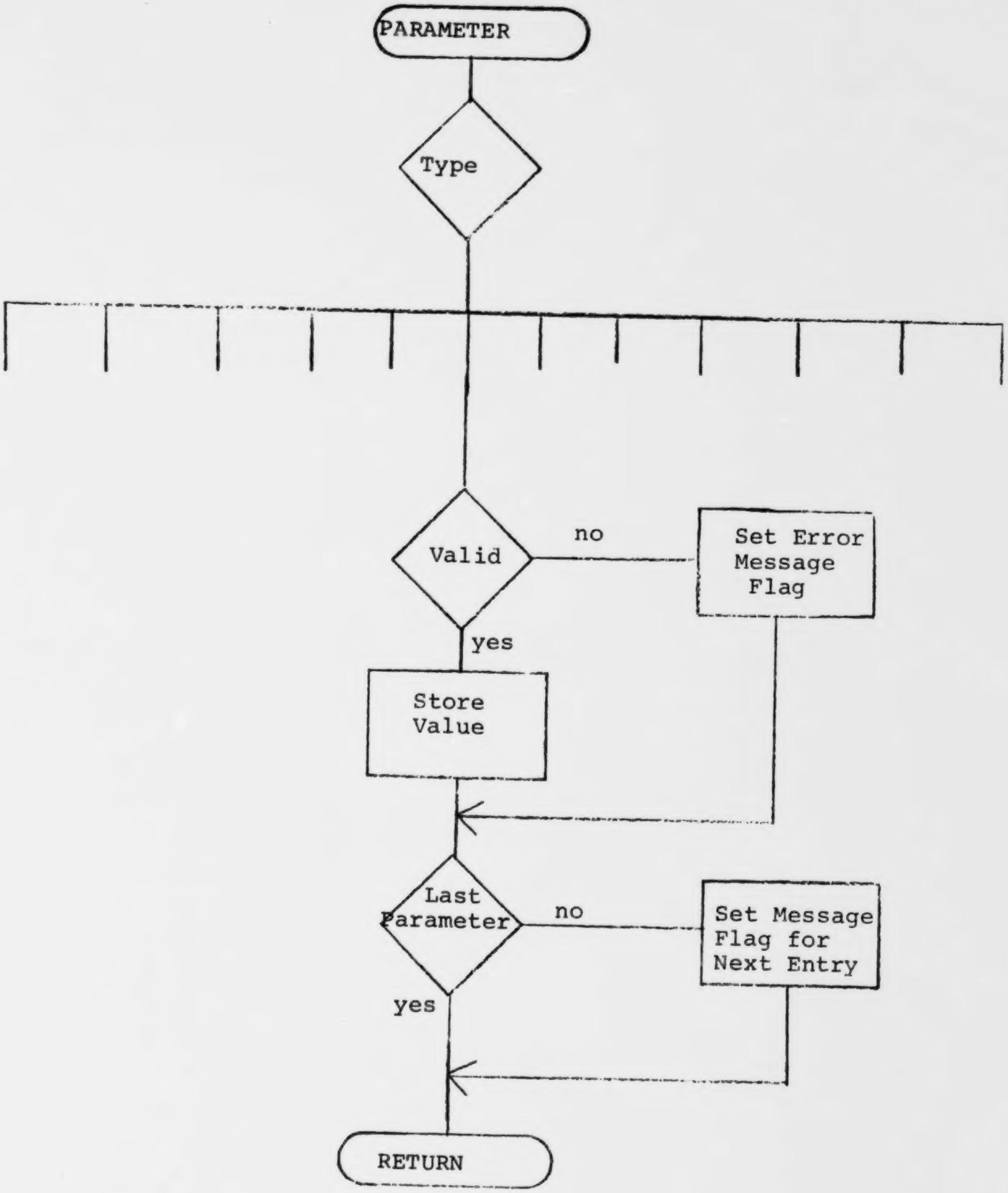

PARAMETER
Type
Valid
no
Set Error Message Flag
yes
Store Value
Last Parameter
no
Set Message Flag for Next Entry
yes
RETURN

Figure 5.2-5. PARAMETER

The command line interpreter interprets keyboard inputs from the operator and formats them for use in the various state modules. The message routine interprets message flags previously set by other routines and passes them to the teletype printer driver.

The event timer maintains elapsed time counters to control the sequence of events and checks required for operation. Flags and states are then set for the sequencing.

The state determination logic checks the state queue to determine which state module should be entered next.

5.2.3 Idle

The idle module includes system and sensor checks and is entered at least once every second. If a system or sensor failure is detected appropriate message flags and states are set to report or correct the failed condition. The following checks are performed:

a. Plugged filter
b. Stack and analyzer velocity equality
c. Instrument out or range

5.2.4 Reset

This module immediately terminates any operations in process and clears flags. Parameters are reset to original values or left with current values. Requests for date and time entries are displayed. All valves, switches and alarms are reset.

5.2.5 Parameter

This module accepts new parameters from the command line interpreter, validates the parameters and stores them. Sequencing, display of current values, and error message display are also controlled in this module. The specific parameters involved are:

a. Sample time interval
b. Log time interval
c. Zero calibration interval
d. Span calibration interval
e. Calibration parameters
f. Calibration limits
g. Alarm limits

5.2.6 Back Purge

This module controls the backpurge sequence. The module has two phases -- initiation and termination. During the initiation phase suspended states are checked and the system cleared if necessary. Once the system is cleared the backpurge valve is opened and the timer set. The system is then returned to idle to await the time out signal.

Upon completion the clogged filter sensor is checked If the filter is clear, the system is returned to the previous state. Otherwise a check is made to determine how many consecutive back purge failures have occurred and appropriate messages flagged. Messages will indicate where a backpurge has started and whether a backpurge has failed or was unable to clear the filter after five attempts.

5.2.7 Zero Calibration

This module controls the sequencing required to establish a "zero" reference point for each sensor. The first phase

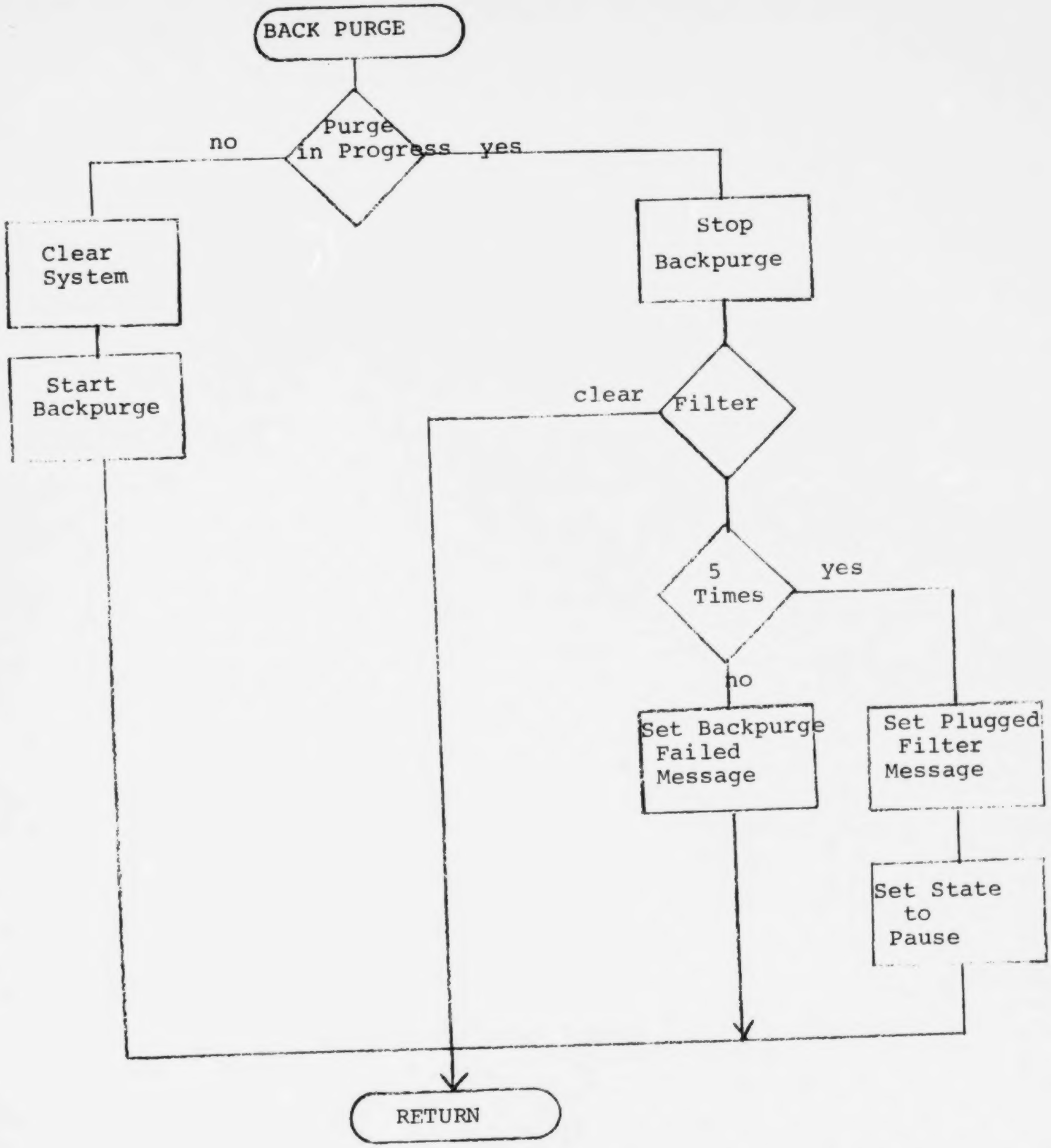

BACK PURGE
Purge in Progress
no
yes
Clear System
Start Backpurge
Stop Backpurge
clear
Filter
5 Times
yes
no
Set Backpurge Failed Message
Set Plugged Filter Message
Set State to Pause
RETURN

Figure 5.2-6. BACK PURGE

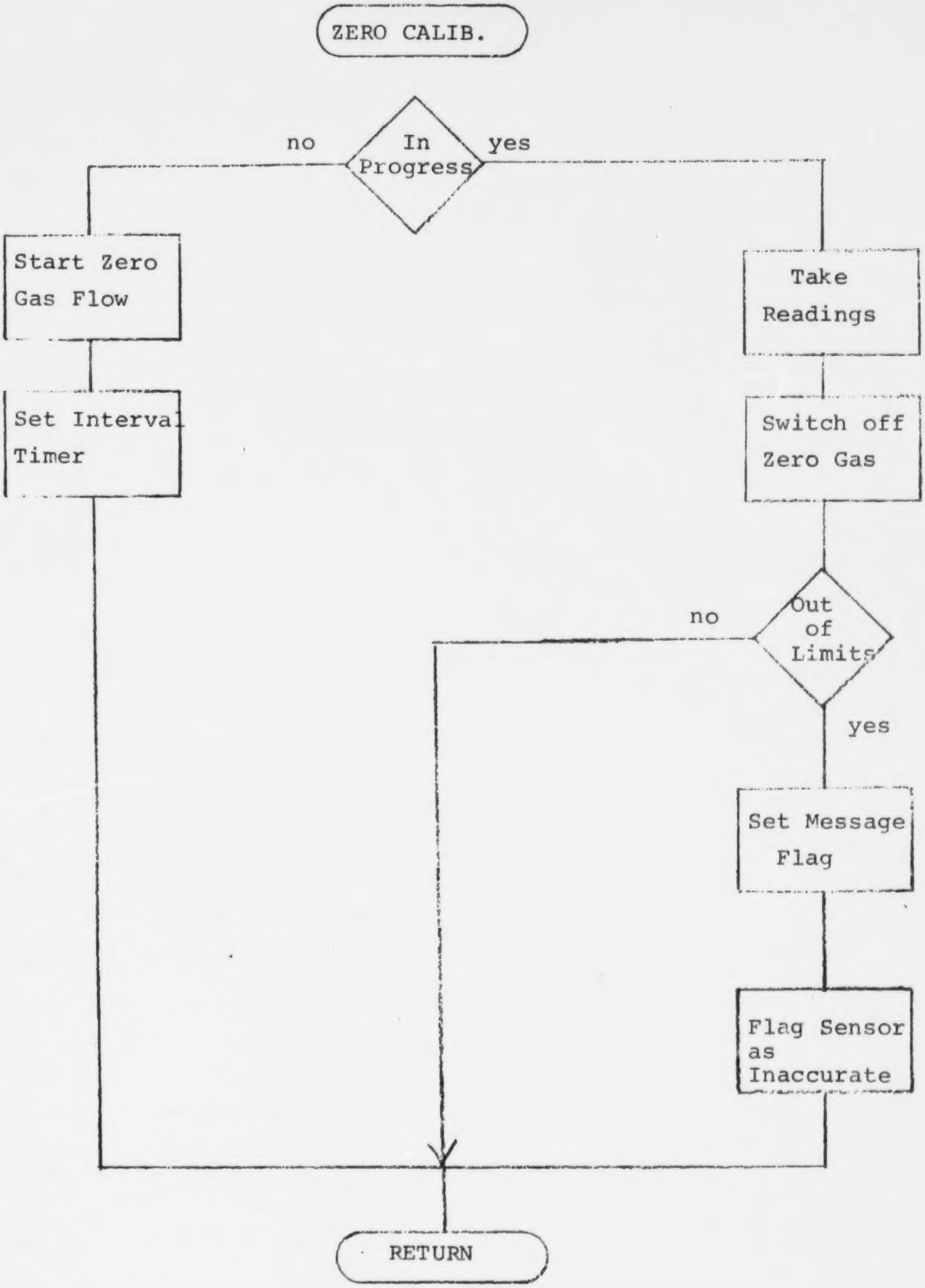

ZERO CALIB.
no
In Progress
yes
Start Zero Gas Flow
Set Interval Timer
Take Readings
Switch off Zero Gas
no
Out of Limits
yes
Set Message Flag
Flag Sensor as Inaccurate
RETURN

Figure 5.2-7. ZERO CALIBRATION

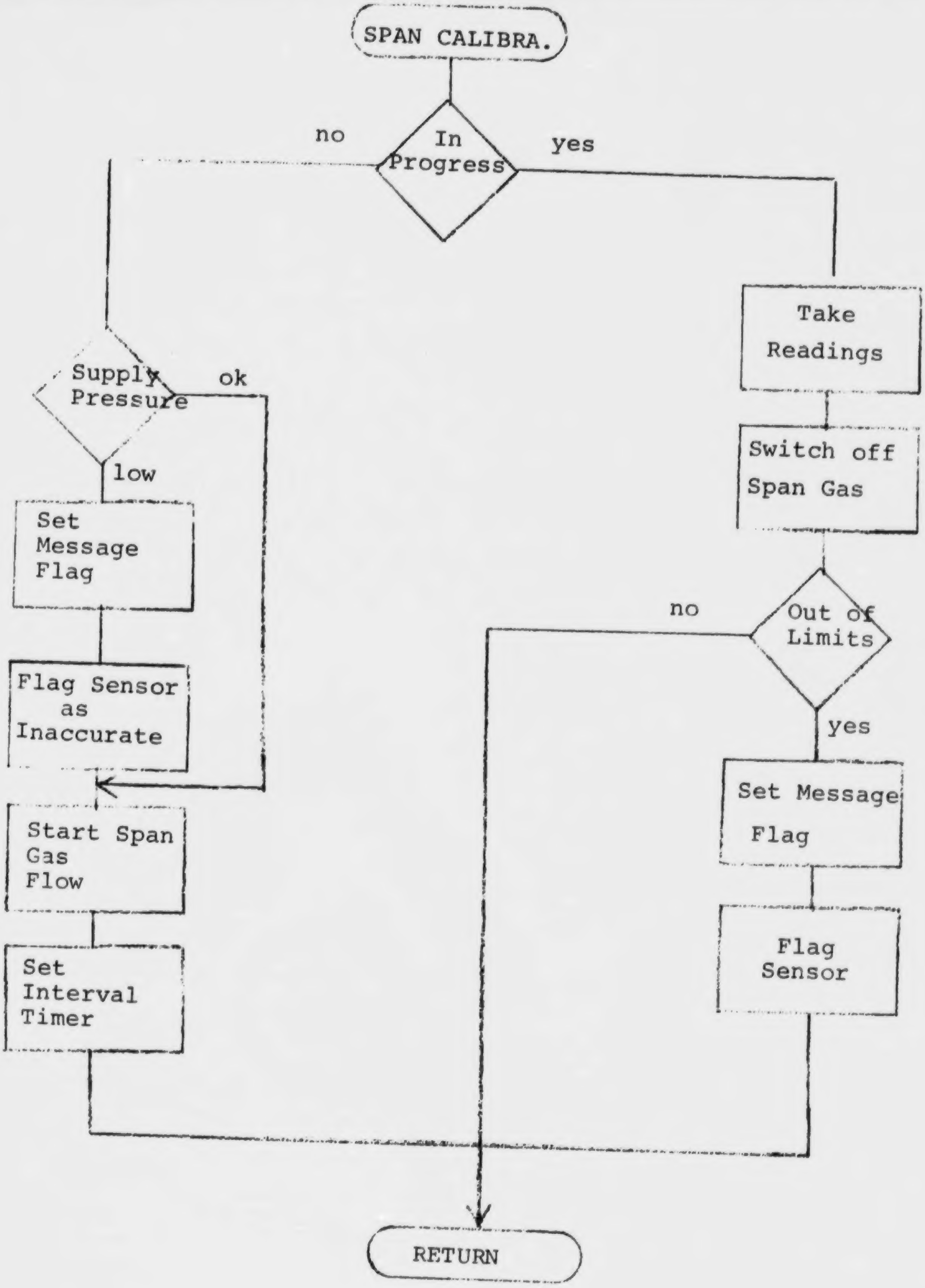

SPAN CALIBRA.
In Progress
no
yes
Take Readings
Switch off Span Gas
Out of Limits
no
yes
Set Message Flag
Flag Sensor
Supply Pressure
ok
low
Set Message Flag
Flag Sensor as Inaccurate
Start Span Gas Flow
Set Interval Timer
RETURN

Figure 5.2-8. SPAN CALIBRATION

consists of switching a valve to allow a known gas to pass through each analyzer and setting the interval timer. During the second phase the sensors are read and the air flow switched back to normal flow. The readings are then checked against the zero calibration limits. Message flags are set for the readings which are out of range and the corresponding sensor flagged as invalid for computation.

5.2.8 Span Calibration

This module controls the sequencing required to obtain calibration values for each sensor. These values, when combined with the zero calibration values, provide sufficient information to convert voltage readings for the full range of the sensors. The first phase consists of checking the low pressure switches for the calibration gas supplies, starting the flow of the span calibration gases and setting the interval timer. Message flags are set if gas supplies are low.

During the second phase the sensors are read and the air flow switched back to normal. The values are then checked against the span calibration limits. Message flags are set for the readings which are out of range and the sensor flagged as invalid for computation. The readings are then used to calculate new conversion and linearization constants.

5.2.9 Monitor

This module reads the sensors, converts the voltages and performs the various limit checks. The first phase consists of equalizing the stack velocity and the sampler velocity by repeated adjustments to a proportional control valve. If the velocities cannot be equalized after five minutes, a message is flagged and the appropriate sensor flagged as inaccurate. Once equalization is achieved the readings are taken and converted. Readings from

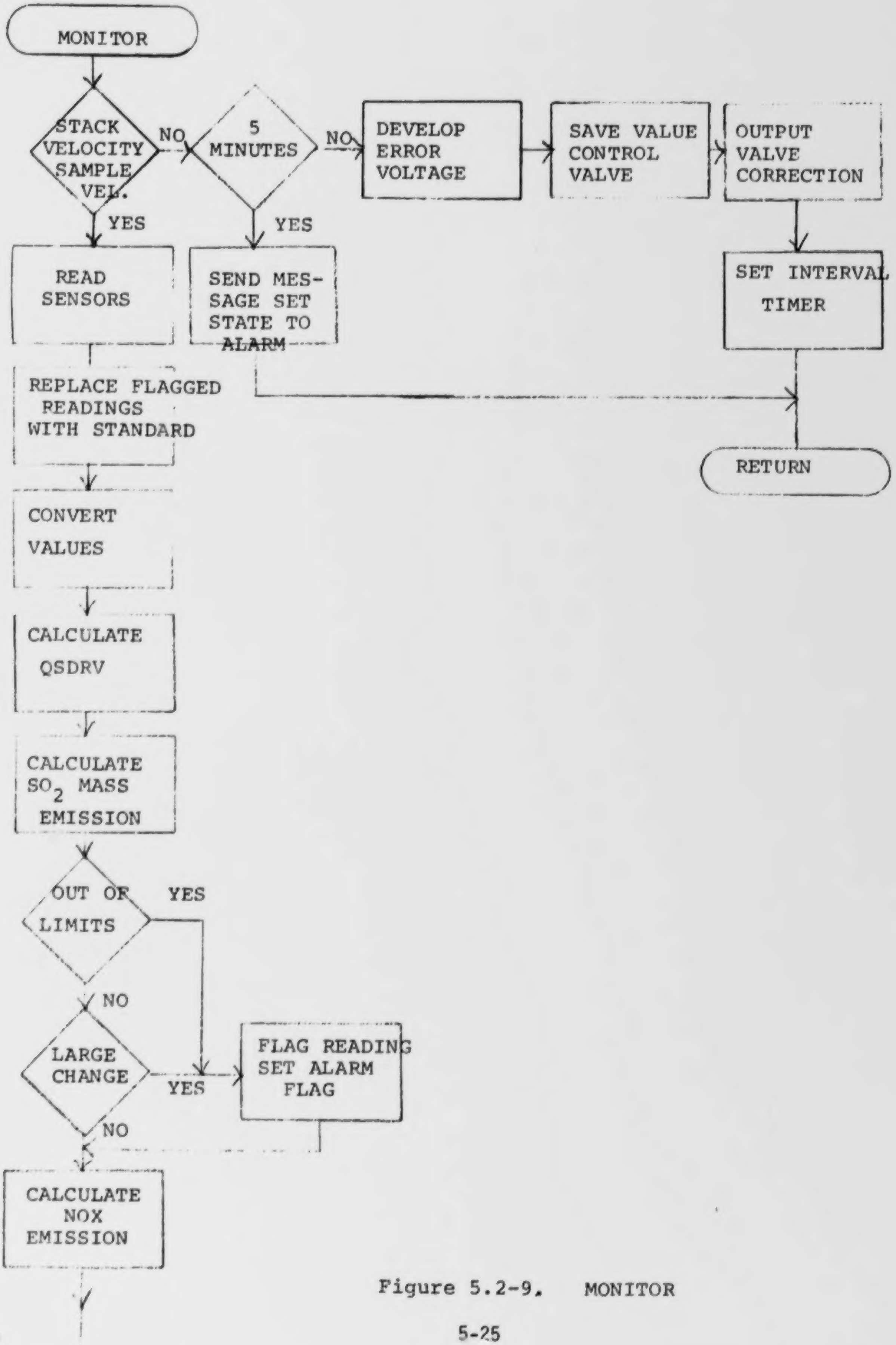

MONITOR
STACK VELOCITY SAMPLE VEL.
NO
5 MINUTES
NO
DEVELOP ERROR VOLTAGE
SAVE VALUE CONTROL VALVE
OUTPUT VALVE CORRECTION
YES
YES
READ SENSORS
SEND MESSAGE SET STATE TO ALARM
SET INTERVAL TIMER
REPLACE FLAGGED READINGS WITH STANDARD
RETURN
CONVERT VALUES
CALCULATE QSDRV
CALCULATE SO_2 MASS EMISSION
OUT OF LIMITS
YES
NO
LARGE CHANGE
YES
FLAG READING SET ALARM FLAG
NO
CALCULATE NOX EMISSION

Figure 5.2-9. MONITOR

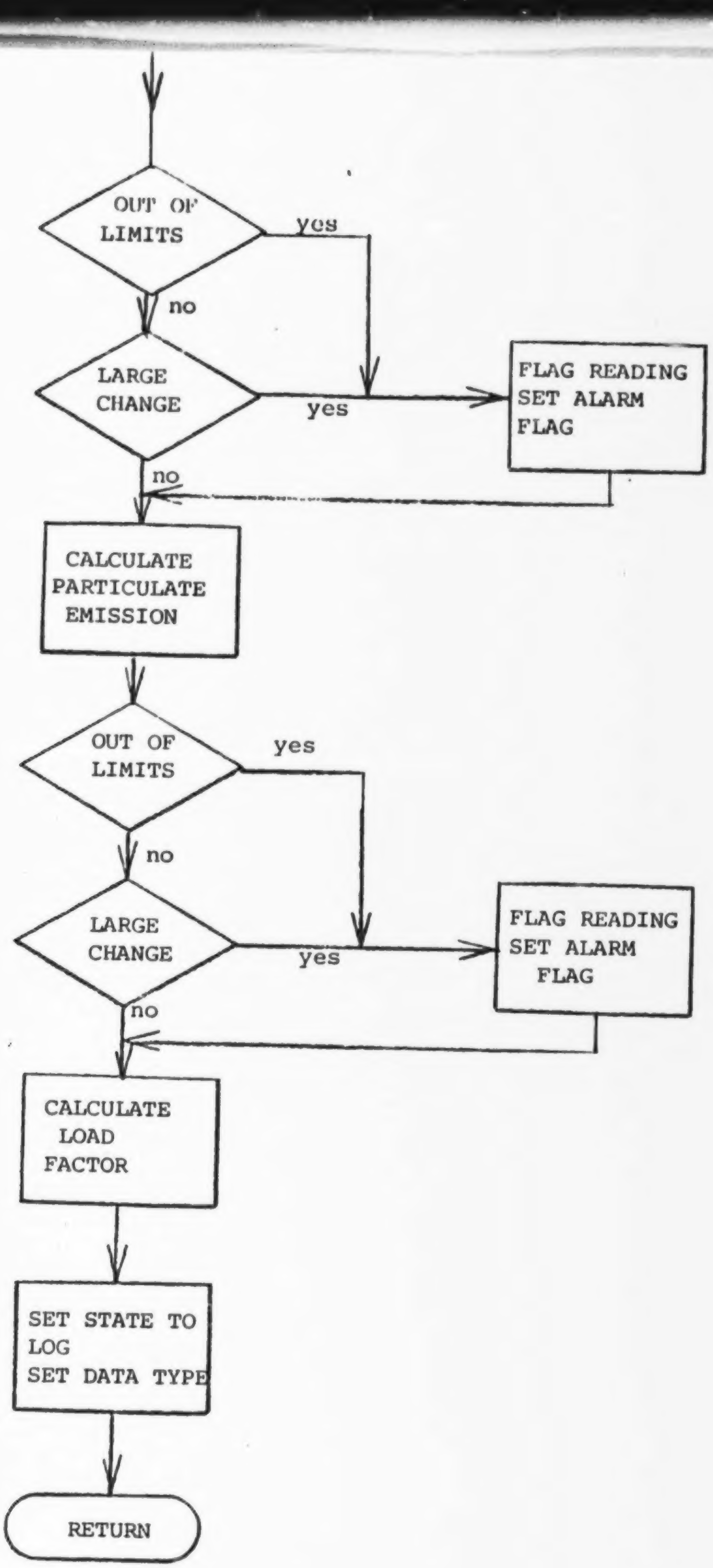

OUT OF LIMITS
yes
no
LARGE CHANGE
yes
FLAG READING SET ALARM FLAG
no
CALCULATE PARTICULATE EMISSION
OUT OF LIMITS
yes
no
LARGE CHANGE
yes
FLAG READING SET ALARM FLAG
no
CALCULATE LOAD FACTOR
SET STATE TO LOG SET DATA TYPE
RETURN

Figure 5.2-9. MONITOR (CONTINUED)

sensors flagged as inaccurate are replaced by standard valves and flagged. The emission values are then calculated, checked against their limits, and appropriate messages and alarms flagged.

5.2.10 Log

This module formats emission values for printing and outputs the values to magnetic tape. If the tape is full or not ready, the state is set to tape termination.

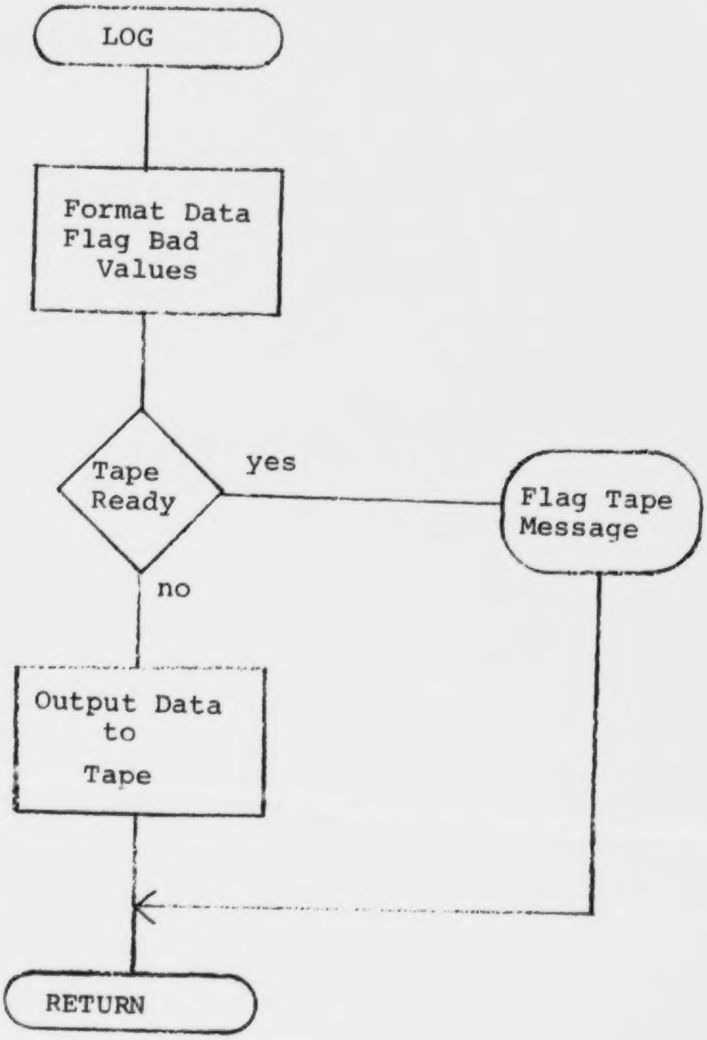

LOG
Format Data Flag Bad Values
Tape Ready
yes
no
Flag Tape Message
Output Data to Tape
RETURN

Figure 5.2-10. LOG

6.0 SYSTEM HARDWARE AND SOFTWARE MODIFICATIONS

After the completion of the Phase I effort, EPA directed STA to modify the Mass Emission Data System to provide supervision and control for a moderate size, single return, closed loop wind tunnel. The system was required to perform the following tasks concurrently:

1. Periodically log instrument readings.
2. Act on operator commands.
3. Control temperature, velocity and humidity of the wind tunnel.
4. Periodically interrogate sense lines for hazardous conditions and respond to hazards which generate interrupts.

The following chapter describes the final system hardware configuration and Chapter 7 describes the system software.

6.1 Hardware Description

The Source Simulator Data/Control System consists of a standard 19 inch rack (74 inches high) housing a Texas Instruments Model 960-A minicomputer, its associated devices (CRU expansion rack), moving head disc, line printer, card reader and teletype. External connections are made to the required external equipment by means of an I/O connector panel located at the rear of the unit.

6.1.1 Computer

The computer selected for this application is the Texas Instruments Model 960A. The unique internal design allows the Model 960A computer to be used easily and efficiently for a wide application of industrial control and data acquisition functions.

Real-time process control and data analysis requires a computer with fast, efficient context switching, easy manipulation of bits and bit-fields and easy exchange of data between the computer and external devices. The Model 960A computer solves these automation problems with the following features: dual mode operation, real time clocks and versatile data input/output. As a result, the Model 960A is well suited to on-line real time operations. Standard features include power fail interrupt and power up interrupt. The Model 960 can accommodate up to 32K of memory and is expandable to 64K with optional external 32K memory chassis.

6.1.2 Memory

The system will be configured with 32K 16 bit words of MOS memory. Features include 750-NS read/write cycle time, power failure protection, automatic parity checking and direct word/bit addressing capability throughout entire memory.

6.1.3 ROM Bootstrap Loader

The read-only-memory bootstrap loader provides for automatic loading of bootstrap programs from input media for gast cold start.

6.1.4 Internal Battery Pack

An internal battery will be provided to maintain the contents of the semiconductor memory in the event main power is interrupted. Memory contents will be preserved for several days to several weeks. The time that the contents will be preserved will depend on the memory size and ambient temperature.

6.1.5 Direct Memory Access Channel

The computer provides high speed input/output through the DMAC which allows up to eight (8) high speed I/O peripheral devices. The DMAC is activated under program control and once started, performs the designated I/O function independently of the program. An interrupt is generated where the I/O function is completed and the status of the task is automatically stored in memory. The magnetic tape transport and the moving head disc will be interfaced through the Direct Memory Access Channel.

6.1.7 Communication Register Unit

The CRU provides the interface between the computer and external devices or peripherals. The CRU provides the capabilities to read, write or test up to a combination of 8,192 input/output lines with a single instruction.

The CRU expansion unit is a rack-mounted chassis containing the device control cards which are described in the following paragraphs.

6.1.7.1 Contactor Data Module

The contactor data module provides the interface between the 960-A computer and devices requiring contact closure outputs and/or isolated inputs. The contactor module has 8 input lines and 8 output lines each of which can be addressed as a single independent line or as a member of a group of lines.

Contactor input lines are diode protected isolated relay coils used to interrogate fault and status indicators on the source simulator control panel; relay inputs are rated at 6 volts D.C., 30 MA.

Contactor output lines are spst contacts used to drive/control source simulator value and solenoid functions. Relay output lines are rated at 250 volts D.C., 3 amps.

The present system configuration is wired to up to 40 input and 40 output lines to be utilized.

6.1.7.2 D/A Converter

Two D/A converter modules each containing 2 D/A channels are used to provide the driving capabilities for the flow velocity, display velocity, temperature and particulate injection. These modules convert a 12-bit, two's complement binary number to a specific analog output signal. A full scale analog output signal range of ±5 volts, 0 to 10 volts or ±10 volts can be selected by a jumper option on the board.

6.1.7.3 Interval Timer Module

The interval timer module will accept a 14-bit binary number from the CPU and count down from this number in pre-selected increments of time. This function is used for internal timing functions required in the program.

6.1.7.4 Interrupt Module

The interrupt module provides the capability for eight interrupt inputs and eight interrupt masks, which are individually addressable by the CPU. Interrupts may be initiated externally from the process or internally by the CPU.

6.1.8 Analog/Digital Converter System

The wide-range analog input system features full scale analog input signals from ±2.50 millivolts to ±10.24 volts, sampled at rates up to 200 samples/second. Channel selection is completely random access with no pattern restrictions. Amplifier gain control that selects the desired input voltage range is program selectable on a per channel basis in 13 binary steps. Input signals are gated by dry three-pole relays, eight channels are contained on each plug-in channel card. Each input sample is amplified by a precision amplifier with 13 programmable gain ranges and digitized by an intergrating analog to digital (A/D) converter. The integrating A/D converter provides the highest degree of rejection to noise present on the input signal lines. Output resolution of the A/D converter is 13 bits binary and the output data format is two's complement binary. The system is presently configured with 40 input channels (5, 8-channel mux cards) and can be easily expanded up to 128 channels with the addition of additional channel cards.

6.1.9 System Console

The ASR-33 Teletype is the control device utilized to display special messages from the system and serves as the input for control functions to the system. The unit operates at a speed of 10 characters per second, and includes a paper tape reader/punch.

6.1.10 Card Reader

The card reader is an asynchronous, photoelectric input device capable of reading 300 cards-per-minute. The input hopper capacity is 600 cards and the unit is a table-top model with single column buffer.

6.1.11 Line Printer

The line printer is a line-at-a-time impact type printer using a multiple-split Helix rotating drum and electro-magnetically activated print hammers. Print rate is 100 characters per second, 132 column, ASCII sub-set code.

6.1.12 Magnetic Disc

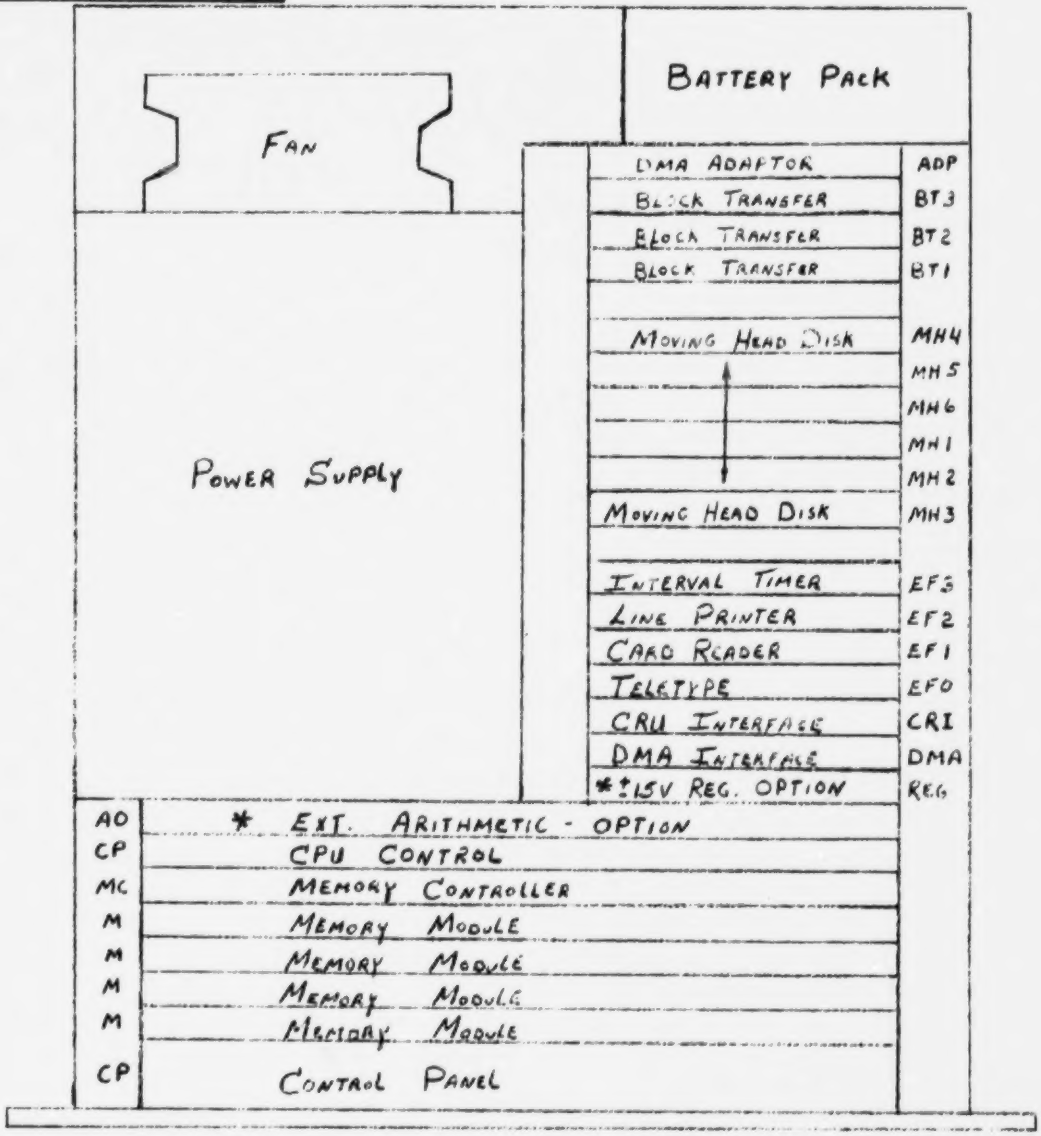
The disc provided for this application is a Diablo Model 31, which will operate with the Model 960A computer through the high speed Direct Memory Access Channel. The Diablo Model 31 is a moving head disc using one 2315 type removable cartridge. Disc capacity is 1.14 million 16-bit words organized in fixed-length sectors. Organization of the disc includes 406 tracks (2 sides), 88.32 word sectors/tracks, and 2200 bits per inch. The disc controller provides the capability for handling up to three (3) additional disc drives for future expansion.

6.1.13 Instrument Connector Panel

A connector panel located in the rear of the system will provide for external connection of all instrumentation. The panel will provide terminal strips which are clearly marked and the terminal shall be physically assigned to the various analyzers, thermo-couplers, and pressure transducers associated with the different experiments. The panel will be labeled with instrument type, associated input channel number and required ground connections.

APPLICATION	
NEXT ASSY	USED ON

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED


Battery Pack
Fan
Power Supply
DMA Adaptor ADP
Block Transfer BT3
Block Transfer BT2
Block Transfer BT1
Moving Head Disk MH4
MH5
MH6
MH1
MH2
Moving Head Disk MH3
Interval Timer EF3
Line Printer EF2
Card Reader EF1
Teletype EF0
CRU Interface CRI
DMA Interface DMA
*±15V Reg. Option REG
AO * Ext. Arithmetic - Option
CP CPU Control
MC Memory Controller
M Memory Module
M Memory Module
M Memory Module
M Memory Module
CP Control Panel

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ±
FRACTIONS ±
DECIMALS ±

MATERIAL:

S-T-A inc.®

PREPARED		
CHECKED		
ENGINEER		

APPROVED
P. Dimouro

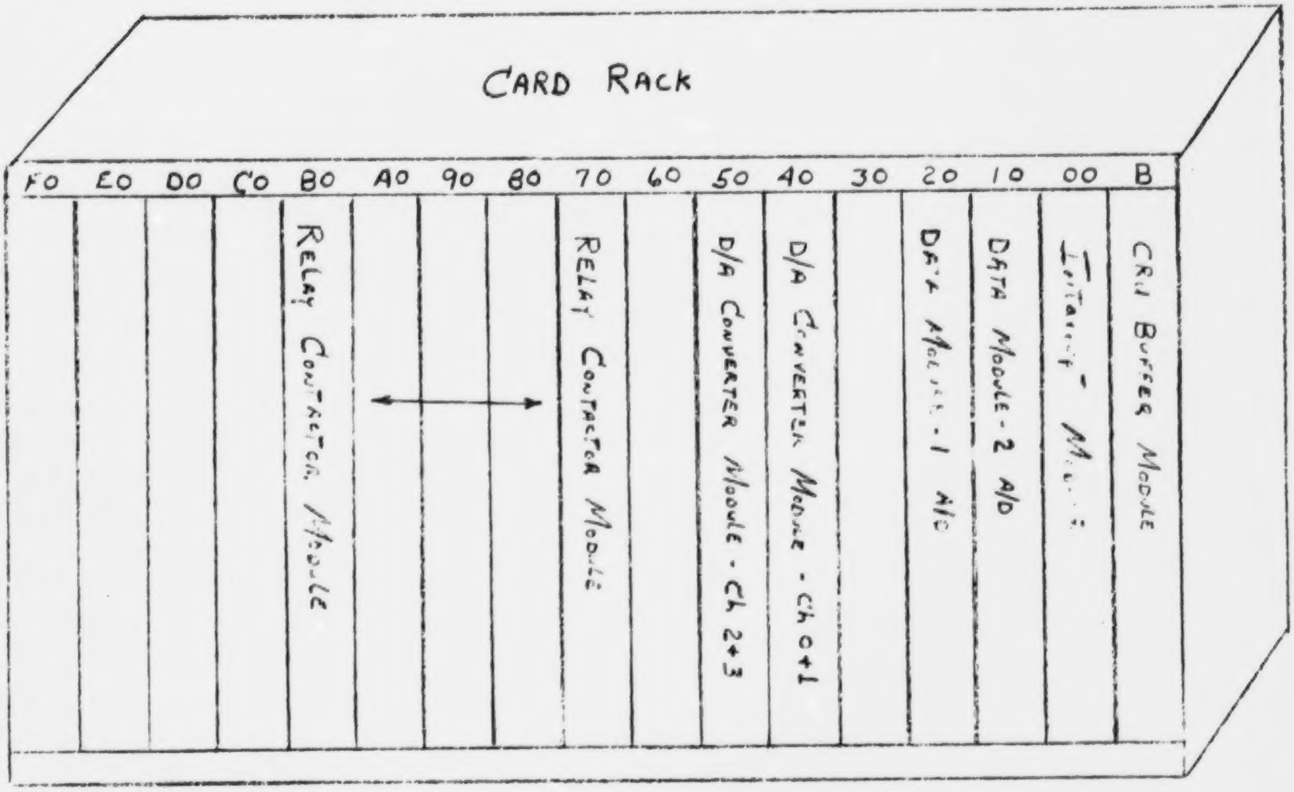
SYSTEMS TECHNOLOGY ASSOCIATES, INC.
2990 TELESTAR COURT, P.O.BOX 2363, FALLS CHURCH, VIRGINIA 22042 / (703) 573-7000

T. I. Model 960A Computer

SIZE	CODE IDENT	DRAWING NUMBER
A	33238	Mass Emission System - EPA

SCALE		SHEET	OF

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	REV	DESCRIPTION	DATE	APPROVED


CARD RACK
F0
E0
D0
C0
B0
A0
90
80
70
60
50
40
30
20
10
00
B
RELAY CONTACTOR MODULE
RELAY CONTACTOR MODULE
D/A CONVERTER MODULE - Ch 2+3
D/A CONVERTER MODULE - Ch 0+1
DATA MODULE-1 A/D
DATA MODULE-2 A/D
INTERRUPT MODULE
CRU BUFFER MODULE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ±
FRACTIONS ±
DECIMALS ±
MATERIAL:

STA inc.®

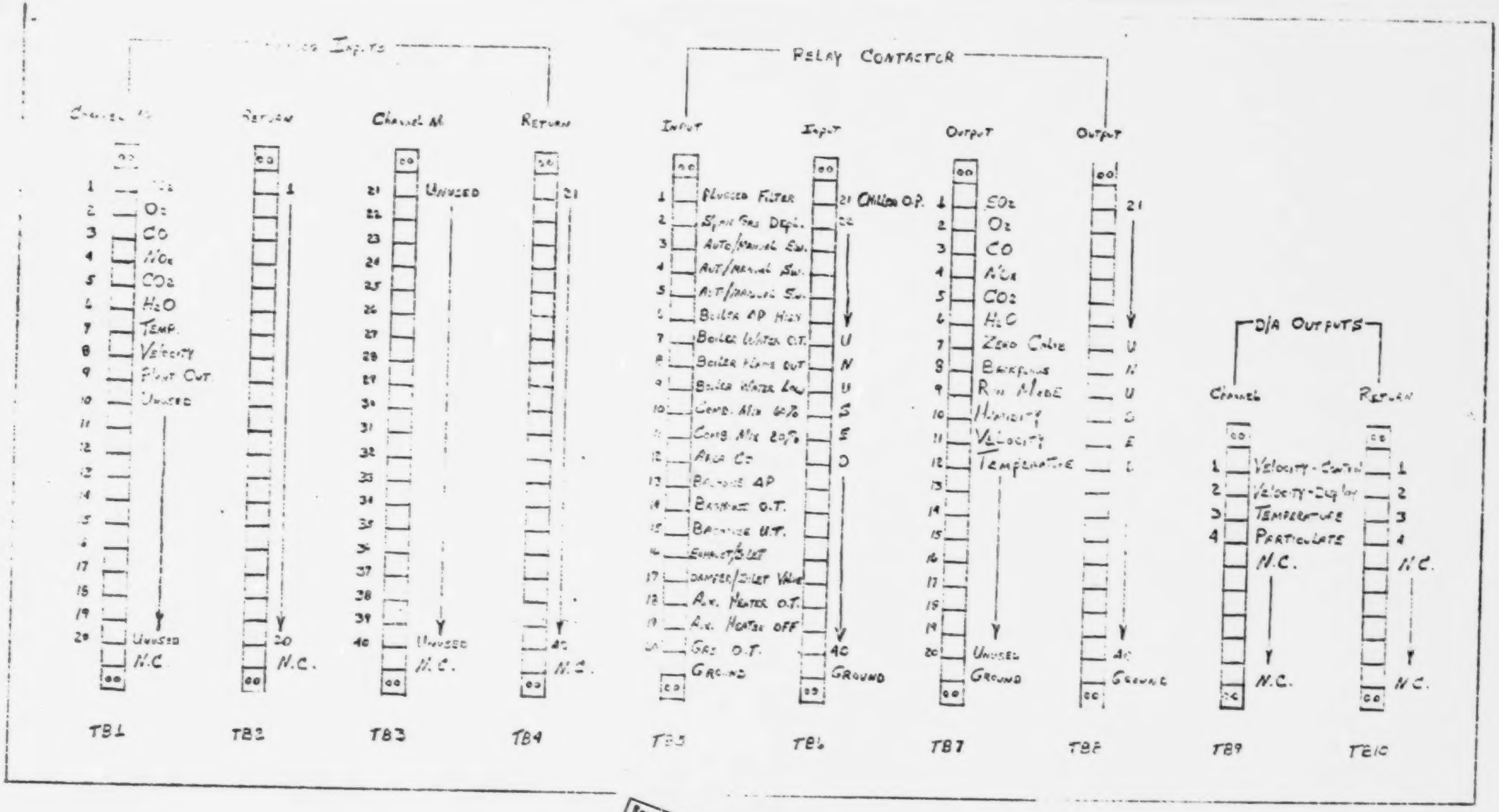
PREPARED
CHECKED
ENGINEER
APPROVED P DIMOURO

SYSTEMS TECHNOLOGY ASSOCIATES, INC.
2990 TELESTAR COURT, P.O.BOX 2363, FALLS CHURCH, VIRGINIA 22042 / (703) 573-7000

T.I. CRU EXPANSION CHASSIS

SIZE A
CODE IDENT 33238
DRAWING NUMBER MASS EMISSION SYSTEM - EVII
SCALE
SHEET OF

1000


Inputs
Relay Contactor
Channel No.
Return
Channel No.
Return
Input
Input
Output
Output
O2
CO
NOx
CO2
H2O
Temp.
Velocity
Plant Out.
Unused
Unused
N.C.
1
20
N.C.
21
Unused
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
Unused
N.C.
21
40
N.C.
Plugged Filter
Span Gas Depl.
Auto/Manual Sw.
Aut/Manual Sw.
Aut/Manual Sw.
Boiler ΔP High
Boiler Water O.T.
Boiler Flame Out
Boiler Water Low
Comb. Mix 60%
Comb. Mix 20%
Area Co
Baghouse ΔP
Baghouse O.T.
Baghouse U.T.
Exhaust/Inlet
Damper/Inlet Valve
Aux. Heater O.T.
Aux. Heater OFF
Gas O.T.
Ground
21 Chiller O.P.
22
UNUSED
40
Ground
SO2
O2
CO
NOx
CO2
H2O
Zero Calib.
Backflush
Run Mode
Humidity
Velocity
Temperature
Unused
Ground
21
UNUSED
40
Ground
D/A Outputs
Channel
Return
Velocity - Control
Velocity - Display
Temperature
Particulate
N.C.
N.C.
N.C.
N.C.
TB1
TB2
TB3
TB4
TB5
TB6
TB7
TB8
TB9
TB10

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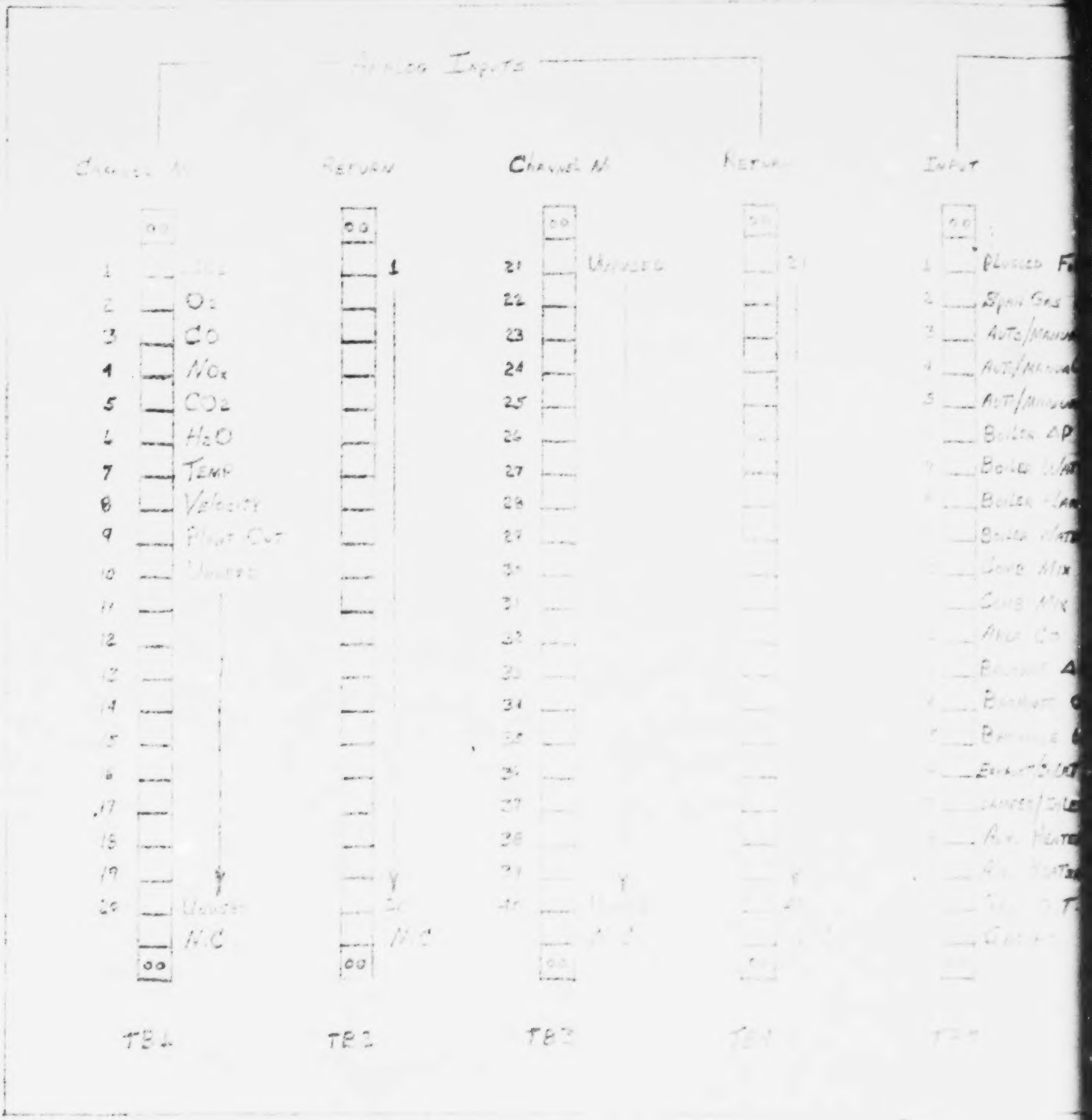
EPA Mass Emission Data System

I/O Connector Panel

Terminal Block Connections


ANALOG INPUTS
CHANNEL No.
RETURN
CHANNEL No.
RETURN
INPUT
O2
CO
NOx
CO2
H2O
TEMP
Velocity
Pitot Out
Unused
Unused
N.C
N.C
Unused
Plugged
Span Gas
Auto/Manual
Auto/Manual
Auto/Manual
Boiler ΔP
Boiler Wat
Boiler Man
Boiler Wat
Comb Mix
Comb Mix
Area Co
Baghouse Δ
Baghouse
Baghouse
Exhaust/Inlet
Damper/Inle
Air Heate
Air Heate
TB1
TB2
TB3

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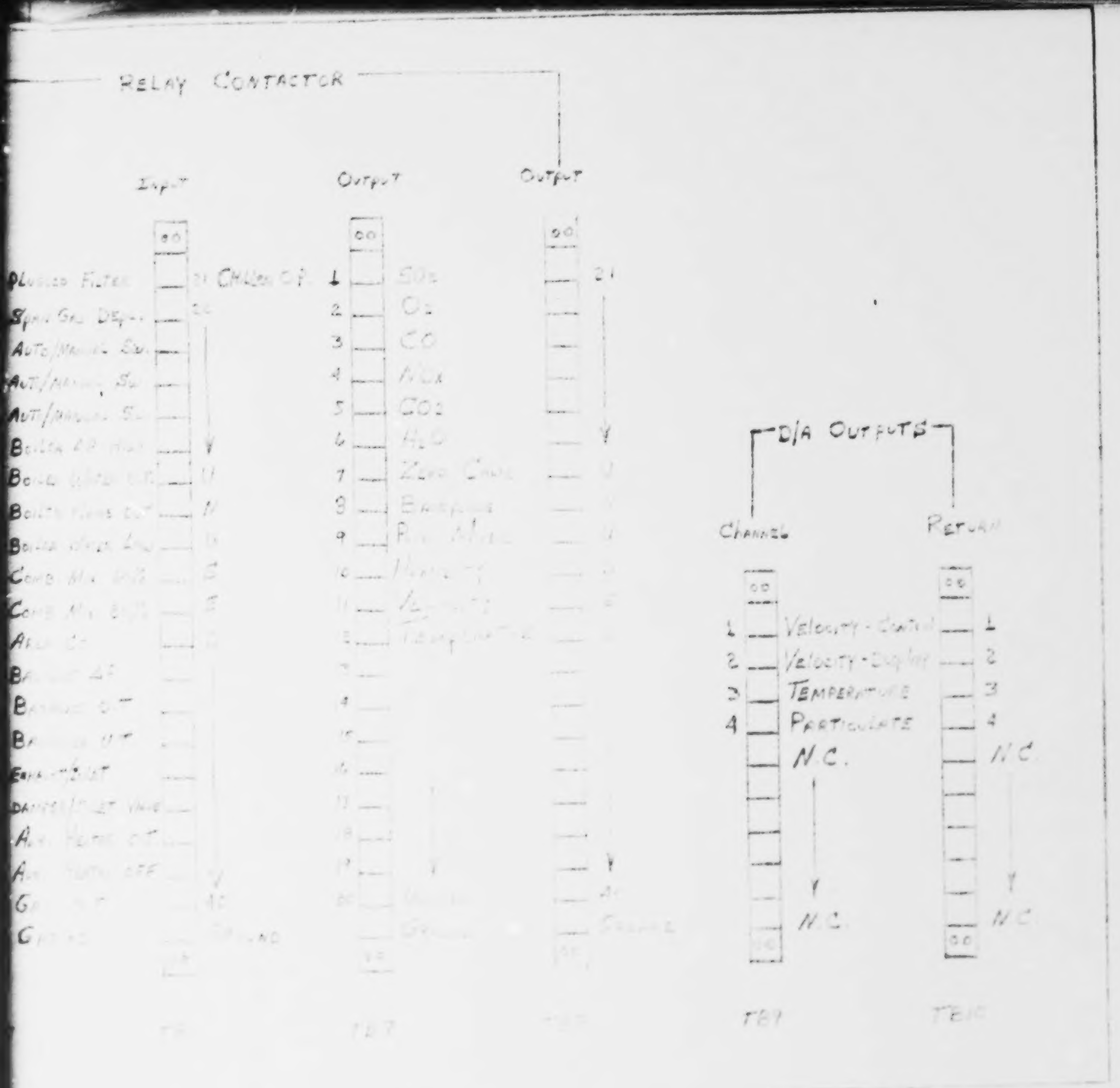
A


RELAY CONTACTOR
INPUT
OUTPUT
OUTPUT
00
PLUGGED FILTER
SPAN GAS DEP...
AUTO/MANUAL SW.
AUTO/MANUAL SW
AUTO/MANUAL SW
BOILER ΔP HIGH
BOILER WATER OUT
BOILER FLAME OUT
BOILER WATER LOW
COMB. MIX. HIGH
COMB. MIX. B...
ALARM CP
BA... ΔP
BA... OUT
BA... OUT
EXHA... / INLET
DAMPER/INLET VALVE
AUX. HEATER OUT
AUX. HEATER OFF
G...
G...
21 CHILLER O.P.
22
UNUSED
GROUND
1 SO2
2 O2
3 CO
4 NOx
5 CO2
6 H2O
7 ZERO CHAN.
8 BACKPURGE
9 RAW MODE
10 HUMIDITY
11 VELOCITY
12 TEMPERATURE
13
14
15
16
17
18
19
20 UNUSED
GROUND
21
UNUSED
20
GROUND
D/A OUTPUTS
CHANNEL
RETURN
1 VELOCITY - CONTROL 1
2 VELOCITY - DISPLAY 2
3 TEMPERATURE 3
4 PARTICULATE 4
N.C.
N.C.
N.C.
N.C.
TB6
TB7
TB8
TB9
TB10

EPA Mass Emission Data System

I/O Connector Panel

Terminal Block Connections

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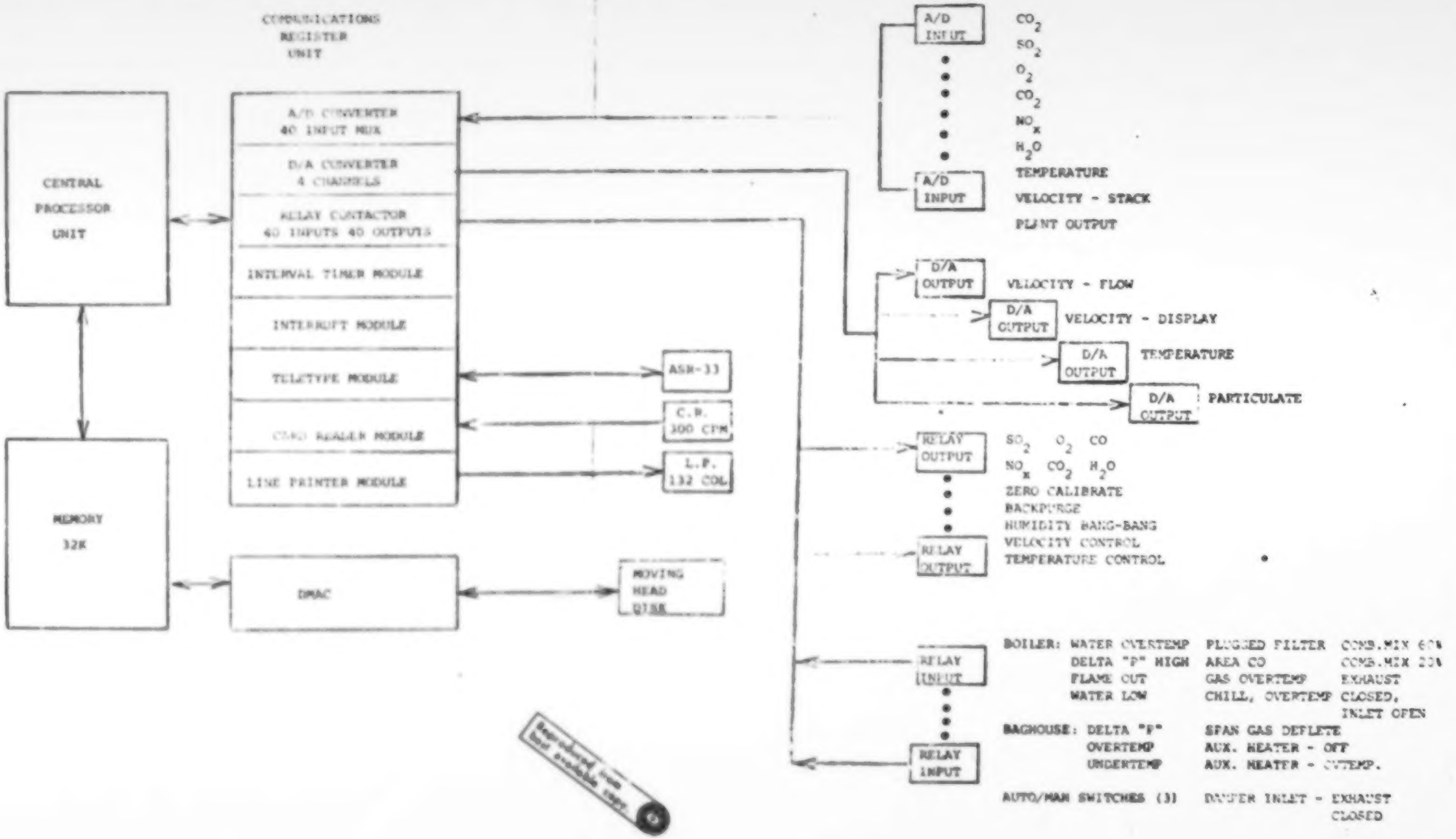
COMMUNICATIONS REGISTER UNIT
CENTRAL PROCESSOR UNIT
MEMORY 32K
A/D CONVERTER 40 INPUT MUX
D/A CONVERTER 4 CHANNELS
RELAY CONTACTOR 40 INPUTS 40 OUTPUTS
INTERVAL TIMER MODULE
INTERRUPT MODULE
TELETYPE MODULE
CARD READER MODULE
LINE PRINTER MODULE
DMAC
ASR-33
C.R. 300 CPM
L.P. 132 COL.
MOVING HEAD DISK
A/D INPUT
A/D INPUT
CO_2
SO_2
O_2
CO_2
NO_x
H_2O
TEMPERATURE
VELOCITY - STACK
PLANT OUTPUT
D/A OUTPUT
VELOCITY - FLOW
D/A OUTPUT
VELOCITY - DISPLAY
D/A OUTPUT
TEMPERATURE
D/A OUTPUT
PARTICULATE
RELAY OUTPUT
RELAY OUTPUT
SO_2 O_2 CO
NO_x CO_2 H_2O
ZERO CALIBRATE
BACKPURGE
HUMIDITY BANG-BANG
VELOCITY CONTROL
TEMPERATURE CONTROL
RELAY INPUT
RELAY INPUT
BOILER: WATER OVERTEMP
DELTA "P" HIGH
FLAME OUT
WATER LOW
PLUGGED FILTER
AREA CO
GAS OVERTEMP
CHILL, OVERTEMP
COMB.MIX 60%
COMB.MIX 20%
EXHAUST CLOSED, INLET OPEN
BAGHOUSE: DELTA "P"
OVERTEMP
UNDERTEMP
SPAN GAS DEPLETE
AUX. HEATER - OFF
AUX. HEATER - OVTEMP.
AUTO/MAN SWITCHES (3)
DAMPER INLET - EXHAUST CLOSED

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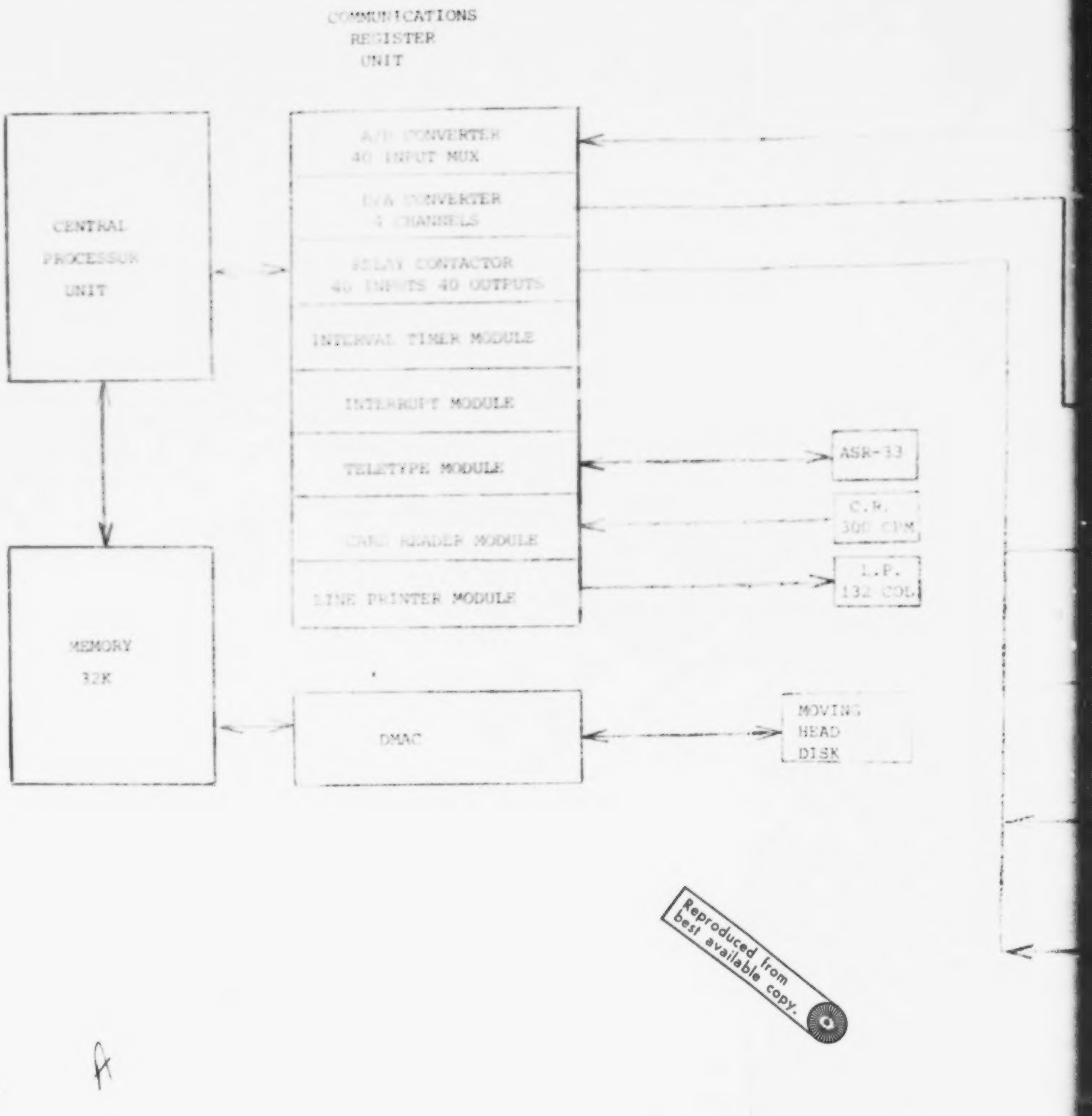
SOURCE SIMULATOR DATA/CONTROL SYSTEM
BLOCK DIAGRAM


COMMUNICATIONS
REGISTER
UNIT
CENTRAL
PROCESSOR
UNIT
A/D CONVERTER
40 INPUT MUX
D/A CONVERTER
4 CHANNELS
RELAY CONTACTOR
40 INPUTS 40 OUTPUTS
INTERVAL TIMER MODULE
INTERRUPT MODULE
TELETYPE MODULE
CARD READER MODULE
LINE PRINTER MODULE
ASR-33
C.R.
300 CPM
L.P.
132 COL.
MEMORY
32K
DMAC
MOVING
HEAD
DISK

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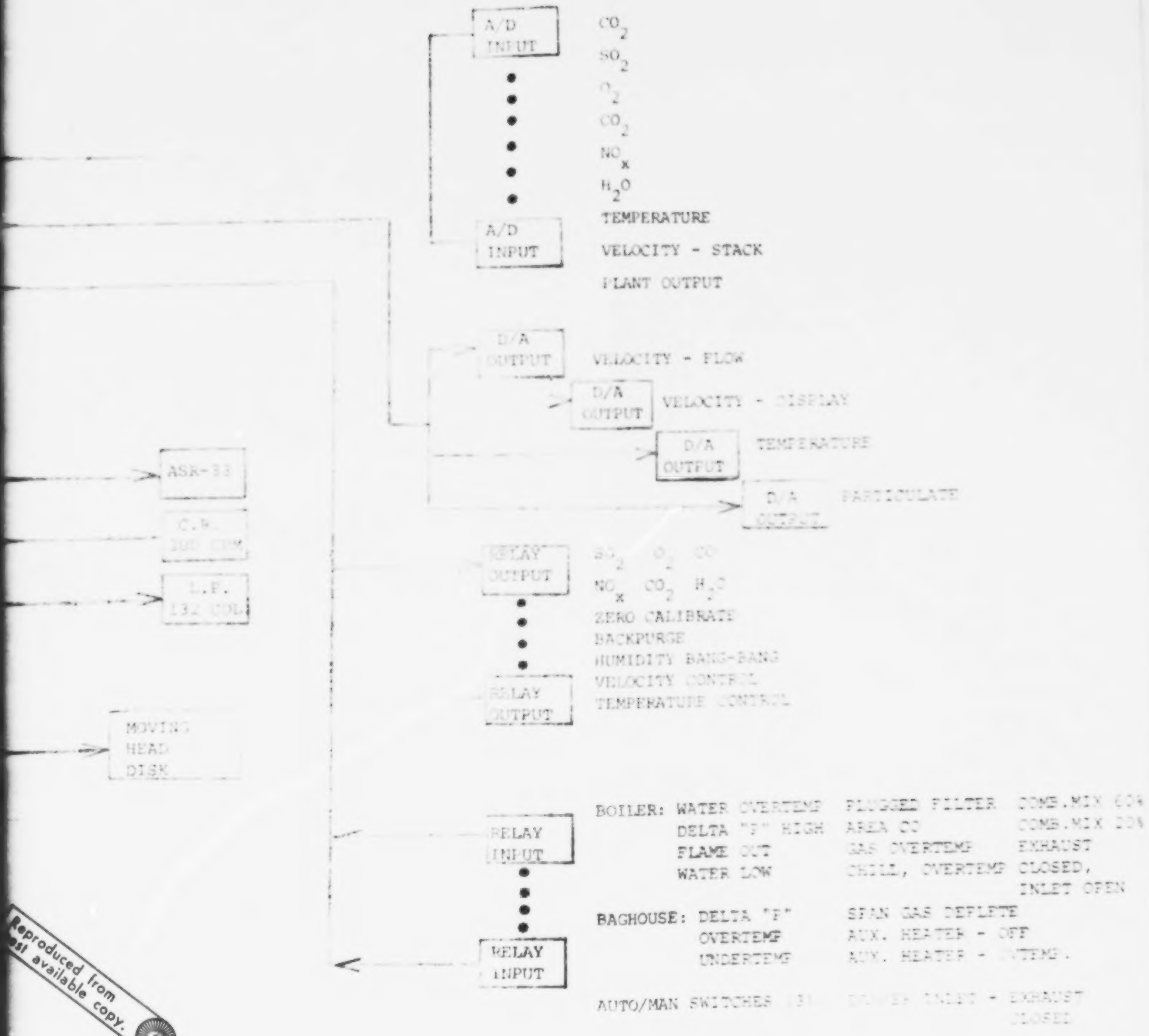
A


A/D INPUT
CO_2
SO_2
O_2
CO_2
NO_x
H_2O
TEMPERATURE
A/D INPUT
VELOCITY - STACK
PLANT OUTPUT
D/A OUTPUT
VELOCITY - FLOW
D/A OUTPUT
VELOCITY - DISPLAY
D/A OUTPUT
TEMPERATURE
D/A OUTPUT
PARTICULATE
ASR-33
C.R. 300 CPM
L.P. 132 COL
RELAY OUTPUT
SO_2 O_2 CO
NO_x CO_2 H_2O
ZERO CALIBRATE
BACKPURGE
HUMIDITY BANG-BANG
VELOCITY CONTROL
TEMPERATURE CONTROL
RELAY OUTPUT
MOVING HEAD DISK
RELAY INPUT
BOILER: WATER OVERTEMP
DELTA "P" HIGH
FLAME OUT
WATER LOW
PLUGGED FILTER
AREA CO
GAS OVERTEMP
CHILL, OVERTEMP
COMB.MIX 60%
COMB.MIX 20%
EXHAUST CLOSED, INLET OPEN
BAGHOUSE: DELTA "P"
OVERTEMP
UNDERTEMP
SPAN GAS DEPLETE
AUX. HEATER - OFF
AUX. HEATER - OVTEMP.
RELAY INPUT
AUTO/MAN SWITCHES (3)
DAMPER INLET - EXHAUST CLOSED

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SOURCE SIMULATOR DATA CONTROL SYSTEM
BLOCK DIAGRAM

I/O ASSIGNMENTS

RELAY CONTACTOR INPUTS

CHANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATION
0	0070	TB5-1	Plugged Filter
1	0070	TB5-2	Span Gas Depleted
2	0070	TB5-3	Auto/Manual Switch
3	0070	TB5-4	Auto/Manual Switch
4	0070	TB5-5	Auto/Manual Switch
5	0070	TB5-6	Boiler ΔP High
6	0070	TB5-7	Boiler Water Overtemperatu
7	0070	TB5-8	Boiler Flame Out
8	0080	TB5-9	Boiler Water Low
9	0080	TB5-10	Combustible Mix. Tunnel 6
10	0080	TB5-11	Combustible Mix. Bypass 20
11	0080	TB5-12	Area CO
12	0080	TB5-13	Baghouse ΔP
13	0080	TB5-14	Baghouse Overtemp
14	0080	TB5-15	Baghouse Undertemp
15	0080	TB5-16	Exhaust Closed, Intake Ope
16	0090	TB5-17	Damper Inlet and Exhaust Values Closed
17	0090	TB5-18	Aux Heater Overtemp
18	0090	TB5-19	Turn Off Aux Heater
19	0090	TB5-20	Gas Overtemp
20	0090	TB6-1	Chiller Overpressure
21	0090	TB6-2	
22	0090	TB6-3	
23	0090	TB6-4	
24	00A0	TB6-5	
25	00A0	TB6-6	
26	00A0	TB6-7	
27	00A0	TB6-8	
28	00A0	TB6-9	
29	00A0	TB6-10	
30	00A0	TB6-11	

HANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATION
31	00A0	TB6-12	
32	00B0	TB6-13	
33	00B0	TB6-14	
34	00B0	TB6-15	
35	00B0	TB6-16	
36	00B0	TB6-17	
37	00B0	TB6-18	
38	00B0	TB6-19	
39	00B0	TB6-20	

I/O ASSIGNMENTS

RELAY CONTACTOR OUTPUTS

CHANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATION
0	70	TB7-1	SO_2
1	70	TB7-2	O_2
2	70	TB7-3	CO
3	70	TB7-4	NO_x
4	70	TB7-5	CO_2
5	70	TB7-6	H_2O
6	70	TB7-7	Zero Calibrate
7	70	TB7-8	Backpurge
8	80	TB7-9	Run Mode
9	80	TB7-10	Humidity (bang-bang)
10	80	TB7-11	Temperature Control
11	80	TB7-12	Velocity Control
12	80	TB7-13	
13	80	TB7-14	
14	80	TB7-15	
15	80	TB7-16	
16	90	TB7-17	
17	90	TB7-18	
18	90	TB7-19	
19	90	TB7-20	
20	90	TB8-1	
21	90	TB8-2	
22	90	TB8-3	
23	90	TB8-4	
24	A0	TB8-5	
25	A0	TB8-6	
26	A0	TB8-7	
27	A0	TB8-8	
28	A0	TB8-9	
29	A0	TB8-10	
30	A0	TB8-11	
31	A0	TB8-12	
32	B0	TB8-13	
33	B0	TB8-14	

CHANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATION
34	B0	TB8-15	
35	B0	TB8-16	
36	B0	TB8-17	
37	B0	TB8-18	
38	B0	TB8-19	
39	B0	TB8-20	

I/O ASSIGNMENTS

ANALOG INPUTS

CHANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATIONS
0	0010	TB1-1	SO_2
1	0010	TB1-2	O_2
2	0010	TB1-3	CO
3	0010	TB1-4	NO_x
4	0010	TB1-5	CO_2
5	0010	TB1-6	H_2O
6	0010	TB1-7	Temp
7	0010	TB1-8	Velocity
8	0010	TB1-9	Plant Output
9	0010	TB1-10	
10	0010	TB1-11	
11	0010	TB1-12	
12	0010	TB1-13	
13	0010	TB1-14	
14	0010	TB1-15	
15	0010	TB1-16	
16	0010	TB1-17	
17	0010	TB1-18	
18	0010	TB1-19	
19	0010	TB1-20	
20	0010	TB3-1	
21	0010	TB3-2	
22	0010	TB3-3	
23	0010	TB3-4	
24	0010	TB3-5	
25	0010	TB3-6	
26	0010	TB3-7	
27	0010	TB3-8	
28	0010	TB3-9	
29	0010	TB3-10	
30	0010	TB3-11	

CHANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATIONS
31	0010	TB3-12	
32	0010	TB3-13	
33	0010	TB3-14	
34	0010	TB3-15	
35	0010	TB3-16	
36	0010	TB3-17	
37	0010	TB3-18	
38	0010	TB3-19	
39	0010	TB3-20	

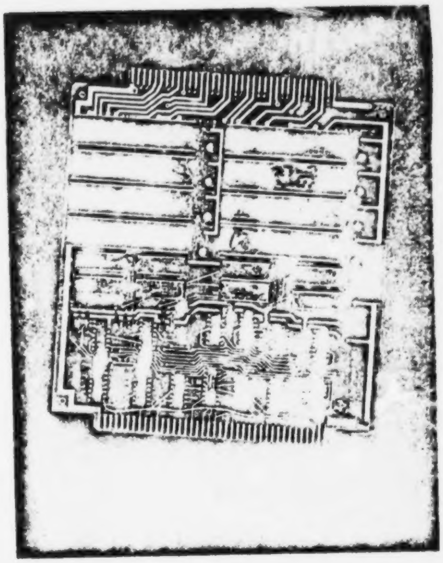
I/O ASSIGNMENTS

D/A OUTPUTS

CHANNEL NO.	CRU ADDRESS	CONNECTOR PANEL INPUT/OUTPUT	SIGNAL DESIGNATION
0	40	TB9-1	Velocity - Control
1	40	TB9-2	Velocity - Display
2	50	TB9-3	Temperature
3	50	TB9-4	Particulate Injection

Velocity Control = 0 to -10 VDC
Velocity Display = 0 to +10 VDC
Temperature = 0 to +10 VDC
Particulate = 0 to +10 VDC

DATA MODULE, CONTACTOR



CONTACTOR MODULE FUNCTION

This module provides two-way communication between the 960A and external relay-controlled devices. Isolated relay contacts are used for outputs. Isolated relay coils are used for inputs. There are eight inputs and eight outputs, each of which may be addressed as a single independent line, or as a member of a group of lines. Each output circuit contains a storage flip-flop that maintains the output until changed by the CPU. The module may be plugged into any CRU port.

CONTACTOR MODULE INTERFACE

Isolated relay coils, 30 ma, are used for inputs. A logic one is represented by a 30 ma current and a logic zero is no current. The input relays have operate and release times of approximately 1 millisecond and .85 millisecond, respectively.

The outputs are used to drive external devices through isolated contacts. These output contacts are capable of handling 50 watts at 250 Vdc maximum or current switched at 3 amperes maximum. The approximate operate and release times for these output contacts are 3 milliseconds and 1.3 milliseconds, respectively. Each output is one SPST relay contact with a logic "1" closing the contact. Connections between the input/output relays and external devices can be made through either an edge connector or a patch panel which provides a pluggable single-line interface.

SPECIFICATIONS

8 Inputs:	6 volt, 30 ma, relay coil
8 Outputs:	SPST contact, 250 Vdc maximum, 3A maximum
Power Requirements:	+5.0 Vdc @ 0.5A

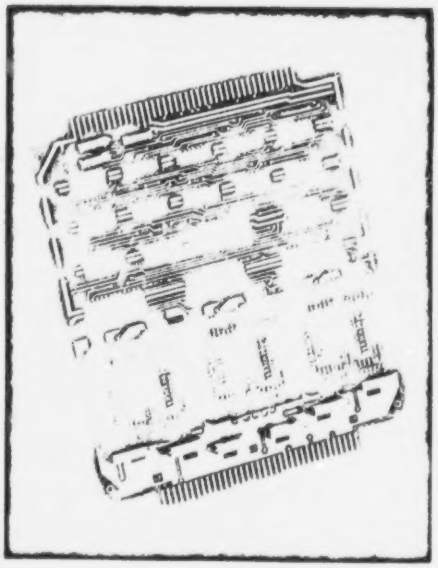
CRU BIT FUNCTIONS FOR THE CONTACTOR MODULE

CRU Output Bit Address*	Function
0	8 General-purpose output contacts
1	
•	
•	
7	
8	Not Used
•	
•	
•	
•	
15	

CRU Input Bit Address*	Function
0	8 General-purpose isolated inputs
1	
•	
•	
7	
8	Not Used
•	
•	
•	
•	
15	

*Add the CRU port address for actual program address.

D/A CONVERTER WITH REGISTERS



D/A CONVERTER MODULE FUNCTION

This module converts a 12-bit, two's complement binary number to a ±5 volt, ±10 volt, to 0 to +10 volt analog signal. The module is available with 1, 2, or 3 channel output options. Internal reference voltage supplies are included on the module.

The D/A card must be plugged into a CRU port wired for ±15 volts in addition to the standard +5 volts.

D/A CONVERTER INTERFACE

All power and logic connections are made through the CRU connector on the bottom edge of the D/A card. Connections between the analog output terminals and the external devices are made with an edge connector on top of the D/A card.

The 16 CRU output bits of the CRU port in which the D/A module is plugged are used to address one of the three analog output channels and to output the 12-bit digital value for conversion. None of the 16 input bits of the port are used by the D/A module. To output an analog value, a Set Output Bit (SETB) instruction may be used to select the proper analog channel and then an Output Field (LDCR) instruction may be executed to transfer the 12-bit character of data from memory to the converter. Five microseconds later the analog output will be stable.

SPECIFICATIONS

Options:	1, 2, or 3 output analog voltages
Output Voltage Range:	±5.0V @ 10.0 ma maximum ±10.0V @ 10.0 ma maximum 0 to +10.0V @ 10.0 ma maximum
Output Accuracy:	±.05% @ 25°C (includes reference supply variation and non-linearity)
Output Temperature Coeefficient:	±30 ppm/°C
Settling Time:	5 microseconds maximum to 0.01% of full scale
Power Requirements:	
Option 1 (1 channel)	+5.0V @ 330 ma, ±15.0V @ 25 ma
Option 2 (2 channels)	+5.0V @ 430 ma, ±15.0V @ 50 ma
Option 3 (3 channels)	+5.0V @ 530 ma, ±15.0V @ 75 ma

CRU Output Bit Address*	Function
0	Not Used
1	1 = Enable Channel 3 Converter
2	1 = Enable Channel 2 Converter
3	1 = Enable Channel 1 Converter
4 • • • • 15	12-bit value to be converted

---

*Add the CRU port address for actual program address.

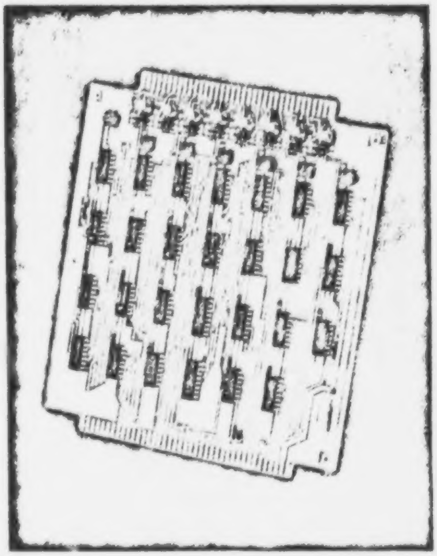
INTERRUPT MODULE

INTERRUPT MODULE FUNCTION

The interrupt module may be used in any port in the CRU to provide 8 interrupt flip-flops and 8 mask flip-flops. Additional modules may be used to provide up to 2048 interrupts. Interrupt lines can be masked out individually (or in groups) by the computer to disable selected interrupts. When any unmasked interrupt line comes true (i.e., 0 volts), the computer receives a CRU interrupt and can scan the interrupt lines to determine which interrupt has occurred.

NOTE

Each 16 I/O Data Module also has the capability of providing a single interrupt line and mask.



INTERRUPT MODULE INTERFACE

The interrupt inputs are negative logic TTL level signals. Zero volts is the "true" or interrupt-on level. Filter capacitor pads for each interrupt input are provided on the module. External connections to the interrupt lines are made at the top edge of the module through either an edge connector or a patch panel which provides a pluggable single-line interface.

SPECIFICATIONS

Inputs:	**8 buffered TTL level interrupts** **0V to 1.0V = Logic "1"** **3.0V to 5.0V = Logic "0"**
Outputs:	**One interrupt active status line for connection to CRU data inputs. Facilitates fast interrupt scan when several interrupt modules are used.**
Power Requirements:	**+5.0 Vdc @ 0.5A**

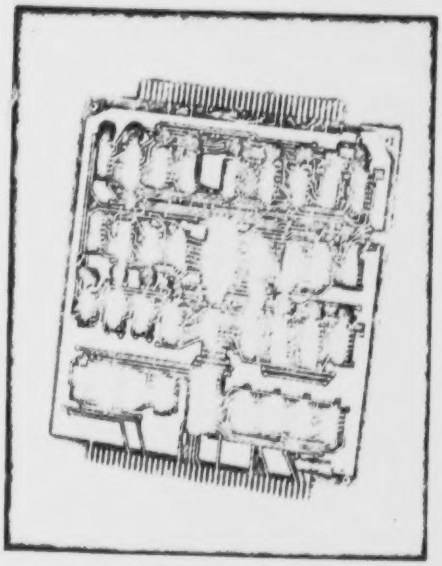
CRU BIT FUNCTIONS FOR THE INTERRUPT MODULE

CRU Output Bit Address*	Function	CRU Input Bit Address*	Function
0 • • 7	0 = Clear interrupts 0–7, respectively 1 = Enable interrupts 0–7, respectively	0 • • 7	Interrupt flip-flops 0–7, 1 = Interrupt
8 • • 15	0 = Mask interrupts 0–7, respectively	8 • • 15	Mask flip-flops 0–7, 1 = Enabled, 0 = Masked

***Add CRU port address for actual program address.**

INTERVAL TIMER MODULE

TIMER MODULE FUNCTION



The interval timer module accepts a 14-bit binary number from the 960A and counts it down to zero in pre-selected (1, 2, 4, or 8 milliseconds) time increments. An interval timer module is required when using the Process Automation Monitors [PAM and PAM(D)]. Normally, one timer module is sufficient for all time interval measurements in a process control application. The Interval Timer Module plugs into one CRU port.

TIMER MODULE INTERFACE

Normally, external connections to the module are not made. Certain clock signals are available on the top edge of the module.

SPECIFICATIONS

Resolution:	1, 2, 4, or 8 milliseconds (selected by wire jumper)
Maximum Count:	16,384 time increments
Interrupt:	At count = 0 timer causes interrupt, but continues to count negative to prevent any loss of real-time due to interrupt servicing by the computer.
Maximum Time Interval Measured:	Unlimited. Software can reset the timer periodically to keep time indefinitely.
Power Requirements:	+5.0 Vdc @ 0.5A

CRU BIT FUNCTIONS FOR THE INTERVAL TIMER

CRU Output Bit Address*	Function
0	0 = Clear Interrupt
1	14-Bit Count Initialization Value from CPU
•	
•	
•	
•	
14	
15	1/0 - Start/Stop Control

CRU Input Bit Address*	Function
0	Timer Interrupt Status: 1 = Interrupt
1	14-Bit Dynamic Count
•	
•	
•	
•	
14	
15	Not Used

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*Add the CRU port address for actual program address.

7.0 SYSTEM SOFTWARE

This chapter describes the software portion of the DCS system. This software was written to interact with a slightly modified T.I. 960A PAM/D Operating System. It is assumed the reader is familiar with the standard PAM/D system.

The software created under this contract can be divided into eight categories:

1. Modifications to PAM/D system
2. Utility subroutines
3. System Common Task
4. Startup Task
5. Operator Communication Task
6. Wind Tunnel Driver Task
7. Fault Check Tasks
8. Sort/Log Task

Each of these categories will be detailed in succeeding sections. However, the tasks and their interrelationships will be summarized in this section.

The SSDCS system is loaded into memory by the following procedure:

1. Install the appropriate disk pack and boot the PAM/D system through standard procedure.

2. Load DEBUG with "!"

3. Issue "BIDT 0055"

4. After approximately 15 seconds, the SSDCS system will be fully loaded and the teletype dedicated to the Operator Communication task.

Task 55 is the Startup Task. Upon initial entry it will automatically bid all the other tasks needed to run the system.

The first task bid by task 55 is task 26 which acts as System Common. It is inactive during system operation. However, it does serve as a central storage area for data which is to be shared by two or more tasks. System Common is the primary means of inter-task communication. This facility required "modification"to the PAM/D system. The modification was the inclusion of a supervisor call processor which merely returns the worker task block address of any specified task in memory. The only other form of inter-task communication used in the system is the ability of one task to unsuspend another task.

After the system has been initiated, the state of the system components are as follows:

Operator Communication (Op-Com):
Waiting for operator input of the first command.

Sort/Log:
This task, which is responsible for automatic periodic logging of sensor readings and final printed results, in a 15 second time delay loop checking System Common for a flag to initiate logging. This flag will be set by the operator communication task on input of the "OPER" command.

Wind Tunnel Driver:
Suspended to be unsuspended by Op-Com on operator input of "SWDT".

Fault Checking Tasks:
The fault checking modules are operating independently of the rest of the system in a 10 second

time delay loop checking important contact closure settings.

The Startup and System Common tasks are in a suspended state.

In order to facilitate system termination, all active tasks are designed to terminate themselves whenever a certain word in System Common becomes negative. System Common automatically terminates itself when it is unsuspended. Upon operator input of the "END" command, OP-COM uses this defined structure to terminate the full system. Due to the various time delays, system shutdown may take up to 2 minutes.

All tasks are in the standard PAM/D format as structured by the PCL compiler. OP-COM and Sort/Log both utilize overlay structures.

7.1 MODIFICATIONS TO THE PAM/D SYSTEM

STA requested Texas Instruments, Inc. to include three modifications to the PAM/D system they were supplying for this contract.

One of the modifications was required to implement System Common communication. STA supplied the code for a supervisor call processor which was incorporated into the system. Any task utilizes this supervisor processor by the following calling sequence

```
L   3,X'8C00'+ID
SXBS   *127
```

Where "ID" is any legal task identification code.

Upon return to the calling task register 3 will contain the worker task block address of the task identified with code "ID". If the task is not currently loaded, register 3 will contain a zero on return.

Currently, this modification is used by all tasks to locate the System Common routine (ID = 26_{16}). All interface to System Common is handled by subroutine CDAT described under Utility subroutines. This processor is also used by Startup to test for load completion and task terminations.

7.1.1 CHEDIT

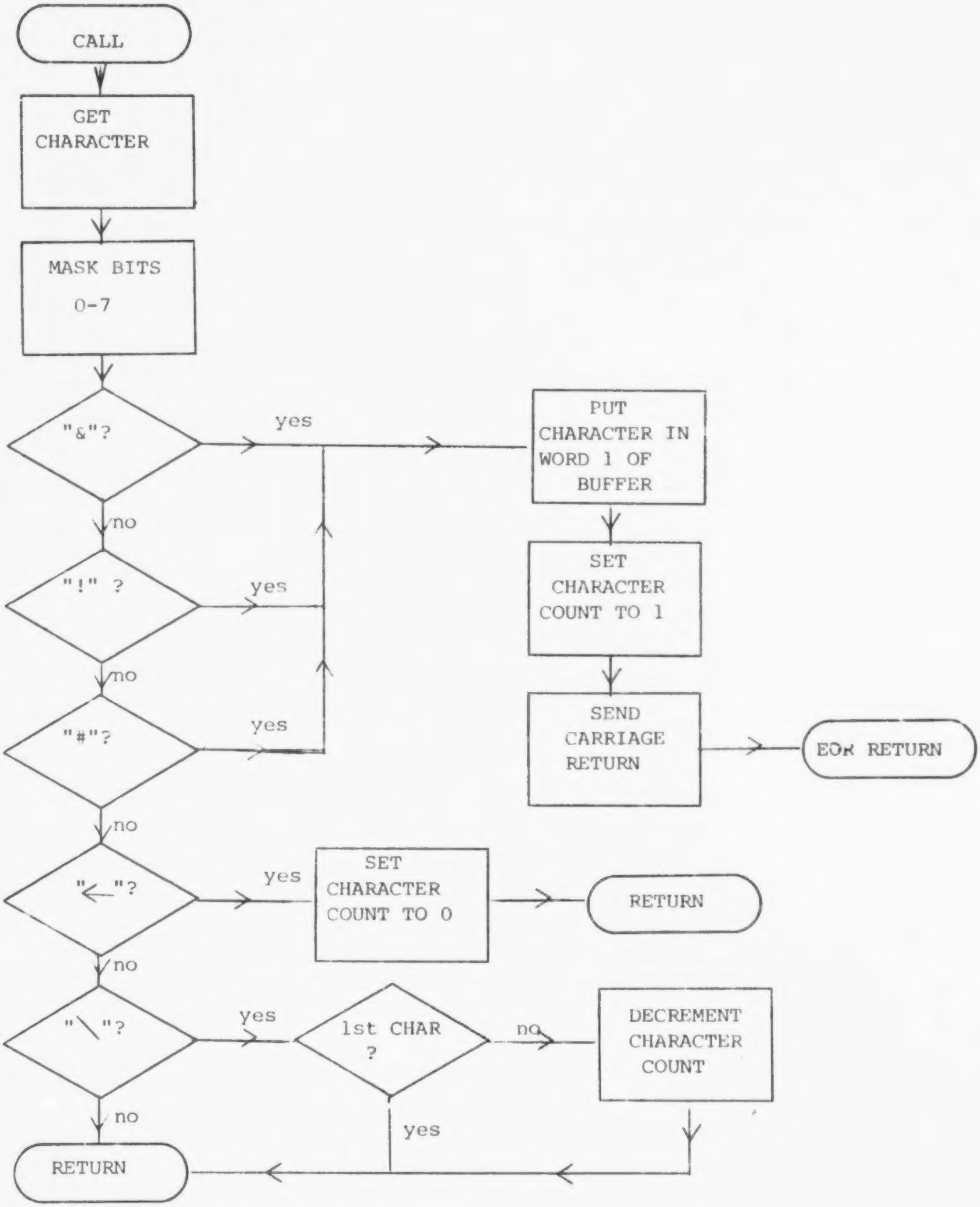
This modification is present in PAM/D regardless of operating mode. Its basic purpose is to check for special characters and take appropriate action. Since CHEDIT is embedded in the PAM/D operating system the actions possible are limited to modification of data in a Physical Record Block and character buffer during a normal "teletype" input output (IOQ) supervisor call. In addition to these modifications, certain characters force an end of record to terminate the supervisor call.

Characters "&", "!" and "#" set PRB word 3 (character count) to 1, are inserted as the first word right justified in the character buffer and force an end of record. A "←" or line delete resets the character count to zero and a "\" or character delete decrements the character count unless the character count is already zero.

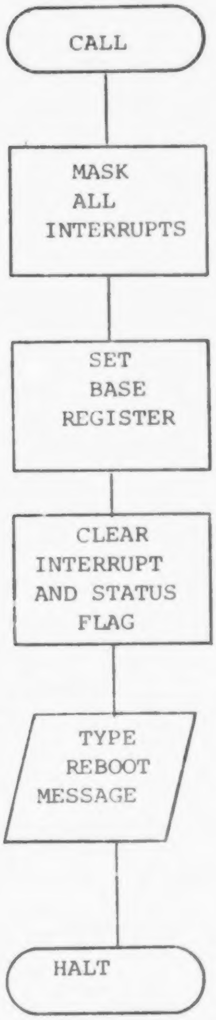
7.1.2 PWRON

This routine is entered whenever power is restored after an interruption of system power and a "reboot" has not yet been made. This routine types "POWER FAIL - REBOOT SYSTEM' on a "stand alone" basis relying on no other part of the PAM/D operating system. Whenever this message is typed, the operator should be sure that all the peripherals are back up before rebooting the system.

CHEDIT


CALL
GET CHARACTER
MASK BITS 0-7
"&"?
yes
PUT CHARACTER IN WORD 1 OF BUFFER
no
"!" ?
yes
SET CHARACTER COUNT TO 1
no
"#"?
yes
SEND CARRIAGE RETURN
EOR RETURN
no
"←"?
yes
SET CHARACTER COUNT TO 0
RETURN
no
"\"?
yes
1st CHAR ?
no
DECREMENT CHARACTER COUNT
no
yes
RETURN

PWRON


CALL
MASK ALL INTERRUPTS
SET BASE REGISTER
CLEAR INTERRUPT AND STATUS FLAG
TYPE REBOOT MESSAGE
HALT

7.2 UTILITY SUBROUTINES

This section describes the following subroutines:

CDAT: Provides simplified System Common communication
LDOV: Facilitates overlay loading from PCL programs
ATOD: Reads and converts specified analog-to-digital converter channels.
DTOA: Outputs given values to specified digital-to-analog channels.
CONCL: Inputs sense lines and outputs control lines.
VREAD: Input teletype line
ICONT: Convert character representation of a number to internal representation.

7.2.1 CDAT

CDAT is a PCL callable subroutine which provides simplified access to System Common. With CDAT, the user can fetch data from, or store data to, System Common. The data elements in System Common are indexed by a "reference pointer" system. Every data variable or array in System Common is uniquely identified by an integer value between 1 and 75. For example, the "name of the current test" is a three word array with reference location 2. Any task requiring access to the test name must call CDAT with the first argument set to +2 or -2.

CDAT uses FORTRAN COMMON for buffer storage. Data returned by CDAT will be deposited in FORTRAN COMMON and data stored by CDAT will be transferred from FORTRAN COMMON to System Common.

Calling Sequence (PCL):

```
CALL CDAT (NUMV, LDISP, LENG)
```

NUMV: ABSOLUTE VALUE (NUMV) represents "reference location" of data. $\text{NUMV} > 0$ means fetch data from System Common. $\text{NUMV} < 0$ means store data in System Common. $1 \leq \text{ABS(NUMV)} \leq 75$

LDISP: LDISP is the word displacement from start of FORTRAN COMMON to the start of the CDAT buffer. First word of FORTRAN COMMON has LDISP = 1.

LENG: LENG is the maximum number of data <u>values</u> to be stored or fetched. If floating point values are being transferred 2*LENG represents the maximum number of words to be transferred. On return, LENG will contain the actual number of values stored or fetched. The word size of data elements in System Common are fixed and the user cannot store or fetch more than is allocated. In any transfer operation either LENG words or the number of words allocated by System Common will be transferred according to which is smaller.

Examples:

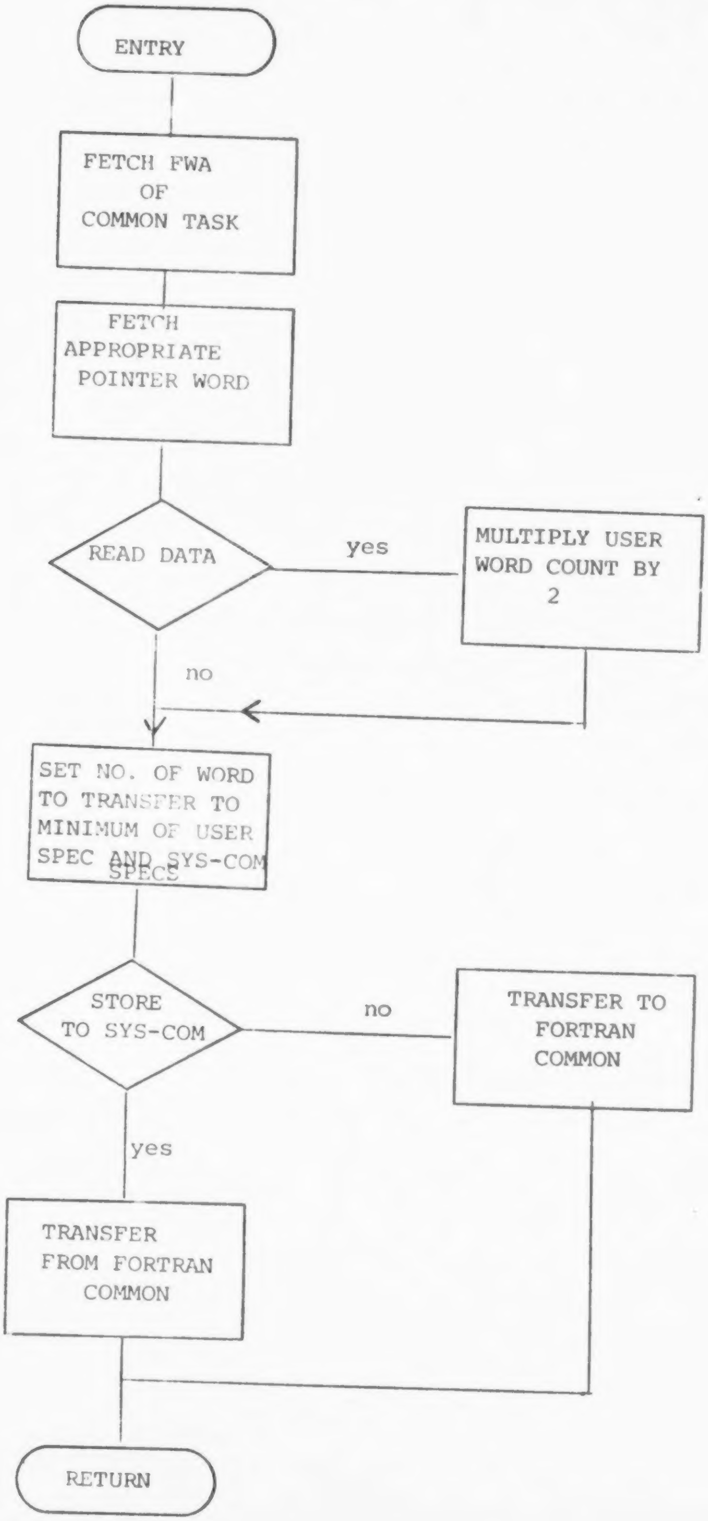
```
COMMON NAME
DIMENSION NAME(5)
    .
    .
    .
LENG=3
CALL CDAT(2,2,LENG)
```

Will return the "current test name" in words NAME(2), NAME(3) and NAME(4).

Method:

For a full explanation of the following flowchart the reader is referred to the discussion of the System Common task.

CDAT


ENTRY
FETCH FWA OF COMMON TASK
FETCH APPROPRIATE POINTER WORD
READ DATA
yes
MULTIPLY USER WORD COUNT BY 2
no
SET NO. OF WORD TO TRANSFER TO MINIMUM OF USER SPEC AND SYS-COM SPECS
STORE TO SYS-COM
no
TRANSFER TO FORTRAN COMMON
yes
TRANSFER FROM FORTRAN COMMON
RETURN

Overlay 4 of file D8 will be loaded. It is assumed that PCL subroutine SORT is first on this overlay.

Method:

The structure of LDOV is quite simple. It constructs a PAM/D "LOAD OVERLAY BLOCK" from the arguments and makes a supervisor LOVLY call.

7.2.2 ATOD

This PCL callable subroutine provides a PCL interface for reading the analog to digital converters. The subroutine call is:

```
CALL ATOD (ARG0,ARG1,ARG2,ARG3)
```

where ARG0 contains a line number from 0 to 39, ARG1 contains a gain from 1 to 15, ARG2 contains the data upon return and aRG3 is a flag. If upon return ARG3 is a zero all other arguments were valid, but if it contains a "1" an error condition existed. An error condition exists if arguments 0 and 1 are not within limits.

This subroutine sets up a Physical Record Block for a normal input-output request (IOQ) superivsor call to device X'20'. Device X'20' should be assigned to the A/D in CRU slot X'0010'.

Example:

```
CALL  ATOD (13,2,NVALU,NERR)
```

This call will cause subroutine ATOD to set up a PRB as follows:

7.2.3 LDOV

LDOV is a non-PCL callable subroutine used to load relocatable disk overlays at execution time. Although it is not PCL callable, it can be called from PCL programs with in line SAL code.

Calling Sequence:

```
REF  ROUTINE
REF  LDOVDD, LDOVPP
      ⋮
BL   0, LDOVPP
DATA ROUTINE
DATA INDEX
DATA LUNO
```

ROUTINE: ROUTINE is the first segment in the overlay being loaded.

INDEX: Represents the overlay number on the overlay file

LUNO: LUNO represents logical unit number of overlay file.

Examples:

```
REF    LDOUPP,LDOVDD         S
        ⋮
BL     0,LDOVPP              S
DATA   SORTDD                S
DATA     4                   S
DATA   X'D8'                 S
CALL SORT
```

XXXX	Worker Task Block Address
X'0000'	Returned Value
X'0000'	Device Address
X'0002'	Channel Number and Gain
X'0620'	Flags and Device Number

The flags are set for read and binary. Device address refers to a multiplexer address and not the CRU address.

7.2.4 DTOA

This PCL callable subroutine provides a PCL interface for outputting values to a specified digital to analog converter. The subroutine call is:

```
CALL  DTOA  (ARG0,ARG1,ARG2)
```

where ARG0 is a channel number from 0 to 3, ARG1 is a value no larger than X'0FFF' (4095) and ARG2 is an error return flag. If arguments 0 and 1 are within limits a "0" is returned in ARG2, but when either is out-of-limits a "1" is returned.

Example:

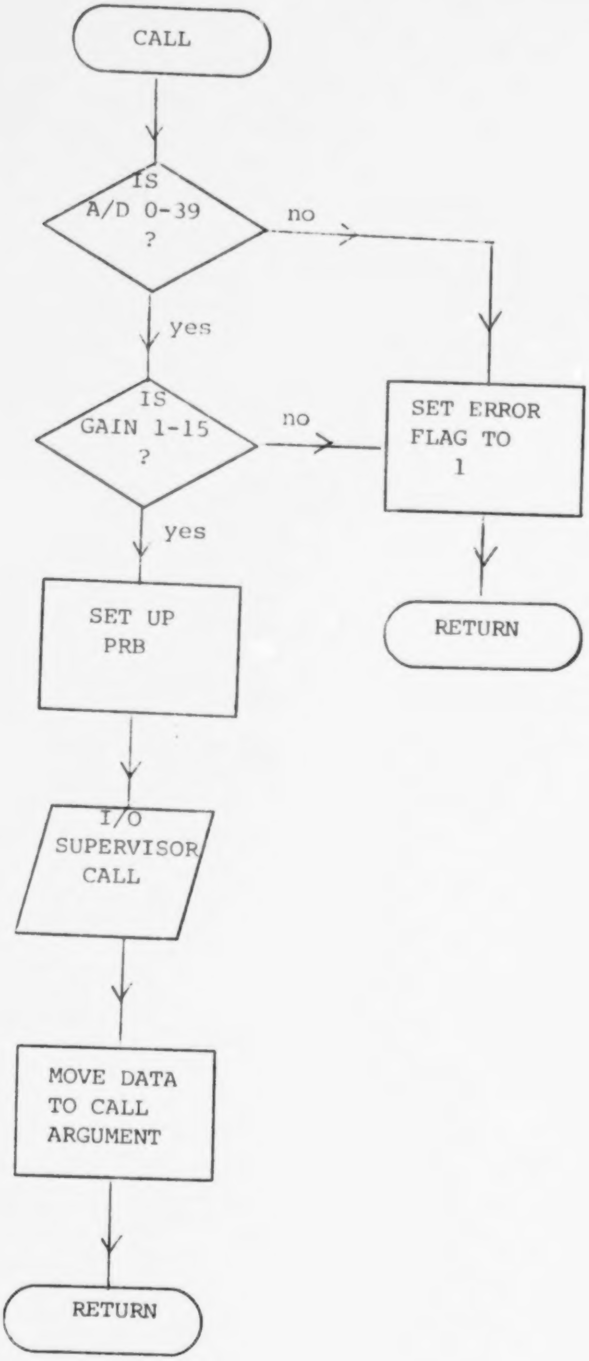
```
CALL  DTOA  (2, 1024,NERR)
```

This call sets up a CRU address of X'0050' in worker register 7 and builds and executes SAL instruction

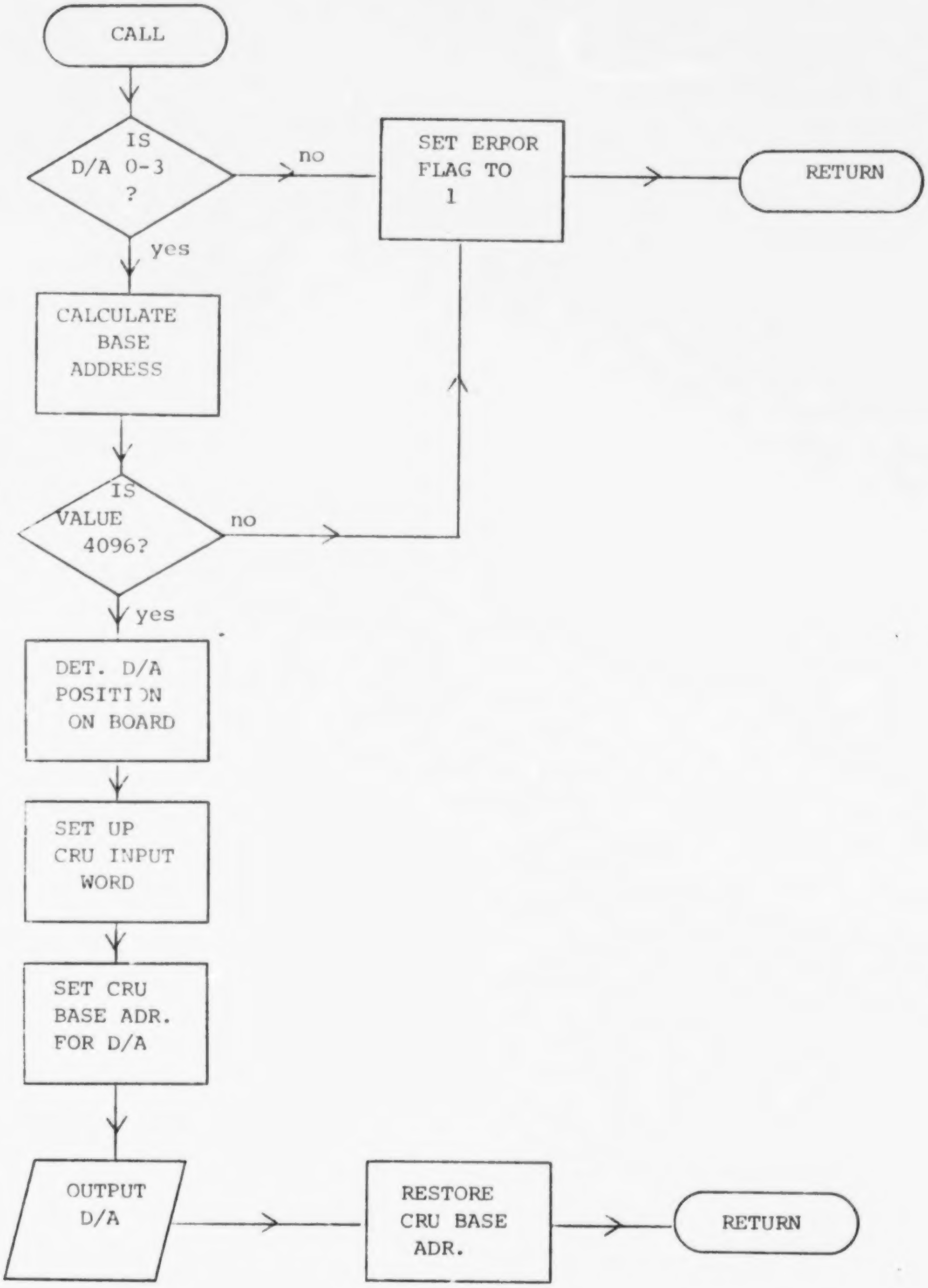
```
"LDCT      (0,0), LCRUD"
```

where location LCRUD contains a X'2001'. X'200' equals 1024. and the data is directed to the first D/A converter on the board at CRUlocation X'0050'. If the D/A has a rnage of 0 to 10 volts, this call will cause a 2.5 volt analog output.

ATOD


CALL
IS A/D 0-39 ?
no
yes
IS GAIN 1-15 ?
no
yes
SET ERROR FLAG TO 1
RETURN
SET UP PRB
I/O SUPERVISOR CALL
MOVE DATA TO CALL ARGUMENT
RETURN

DTOA


CALL
IS D/A 0-3 ?
no
SET ERROR FLAG TO 1
RETURN
yes
CALCULATE BASE ADDRESS
IS VALUE 4096?
no
yes
DET. D/A POSITION ON BOARD
SET UP CRU INPUT WORD
SET CRU BASE ADR. FOR D/A
OUTPUT D/A
RESTORE CRU BASE ADR.
RETURN

7.2.5 CONCL

This PCL callable subroutine implements two types of contact closure actions. This routine may either read or set a specified contact closure. The subroutine call is:

```
CALL  CONCL  (ARG0,ARG1,ARG2,ARG3)
```

where ARG0 contains a contact closure number from 0 thru 39, ARG1 defines type of call (0 for comparing and 1 for setting), ARG2 defines bit setting (0 or 1) upon call and upon return will contain a 1 if CRU reading and specified value agree and a 0 otherwise and ARG3 is an error flag which upon return contains a "0" if ARG0 was within limits and a "1" if it was out of limits.

Examples:

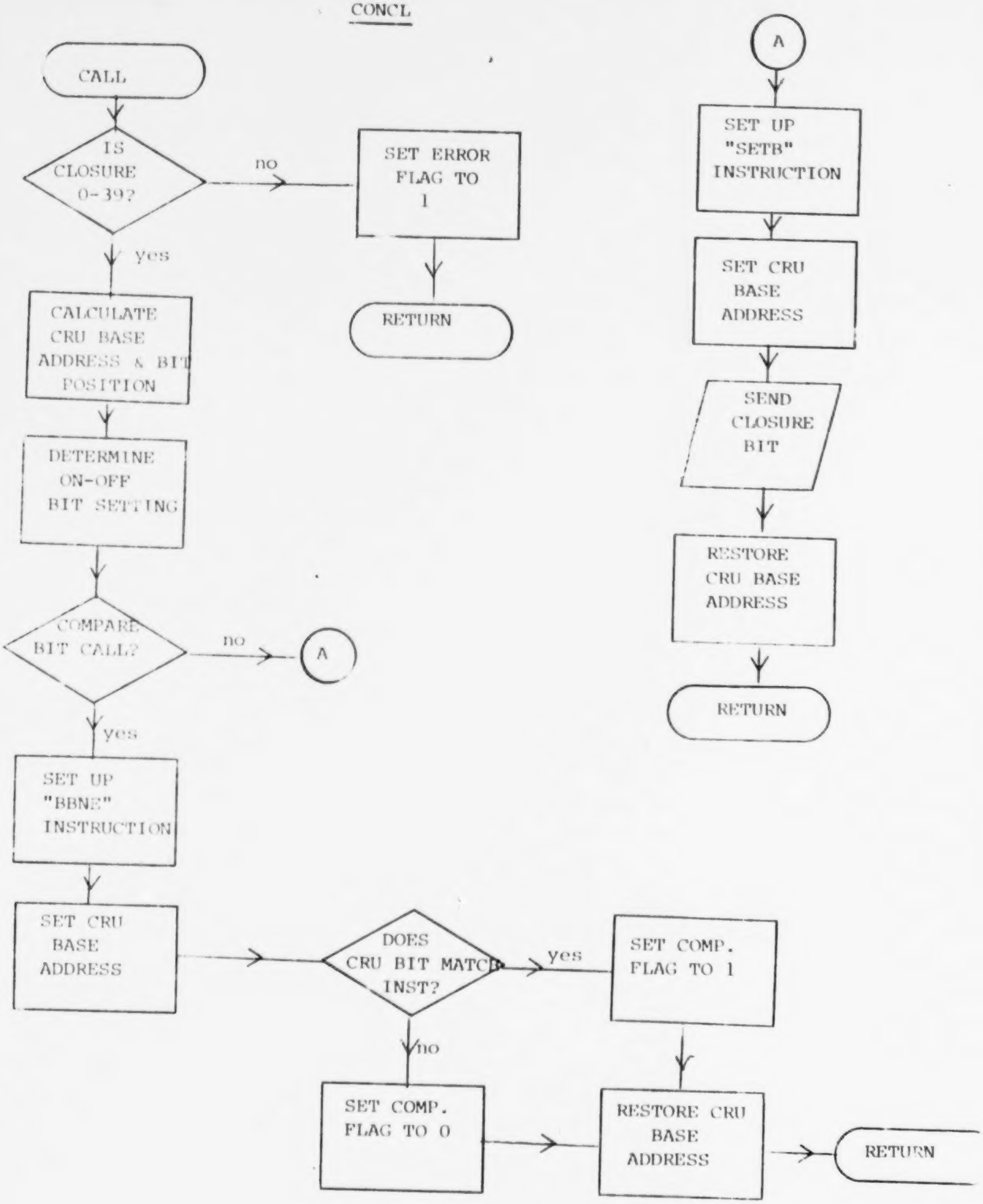
a) CALL CONCL (25,0,LSET,LERR)
b) CALL CONCL (13,1,1,LERR)

If LSET=1, then example "a" will build and execute the SAL instruction "BBNE 2,1,@UEBT" with worker register 7 set to X'00A0'. If the specified contact closure is "1" then the next instruction is executed setting LSET to 1, restoring worker register 7 and returning. Otherwise, the instruction at label "UEBT" is executed setting LSET to 0, restoring worker register 7 and returning.

In example "b", SAL instruction "SETB 5,1" will be built and executed with worker register 7 set to X'0080'. Whenever a bit is set, ARG2 of the call remains unmodified.

In each case the CRU base address was determined by the formula: LSET = X'70' + ARG0/8*X'10' and the formula: LBIT = ARG0 - ARG0/8*8 determines the contact closure within the designated CRU slot.

CONCL


CALL
IS CLOSURE 0-39?
no
SET ERROR FLAG TO 1
RETURN
yes
CALCULATE CRU BASE ADDRESS & BIT POSITION
DETERMINE ON-OFF BIT SETTING
COMPARE BIT CALL?
no
A
yes
SET UP "BBNE" INSTRUCTION
SET CRU BASE ADDRESS
DOES CRU BIT MATCH INST?
yes
SET COMP. FLAG TO 1
no
SET COMP. FLAG TO 0
RESTORE CRU BASE ADDRESS
RETURN
A
SET UP "SETB" INSTRUCTION
SET CRU BASE ADDRESS
SEND CLOSURE BIT
RESTORE CRU BASE ADDRESS
RETURN

7.2.6 VREAD

This PCL callable subroutine is used to input variable length data with the "teletype". This subroutine was designed ti circumvent a problem with the supplied PCL. Whenever a fewer number of characters than specified by the PCL read format are entered, the PAM/D operating system types a task error message, prints a core dump and disables the PCL task containing the read statement.

This subroutine also has a second function. Whenever an "!" is entered subroutine VREAD bids the debug task and terminates the task containing the call to VREAD. When the operations using the debug task have been completed the task containing VREAD may be rebid by the debug task.

The subroutine call is:

```
CALL  VREAD (ARG0, ARG1)
```

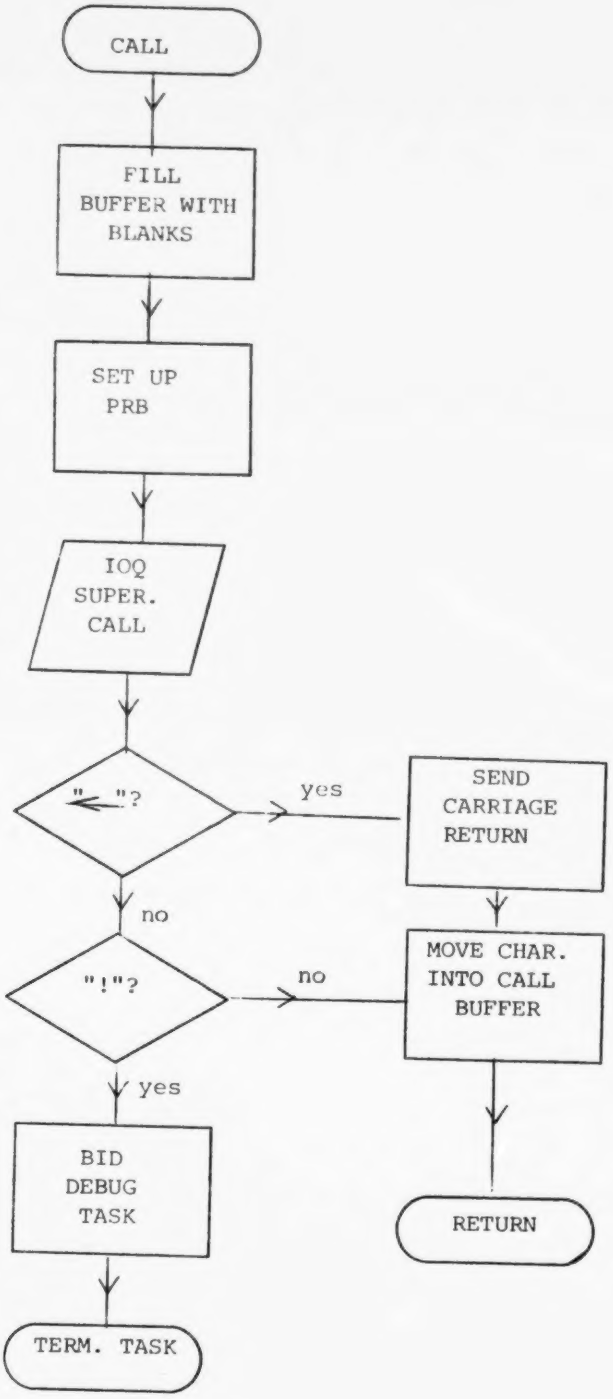
where ARG0 is an integer array and ARG1 is the character count.

Example:

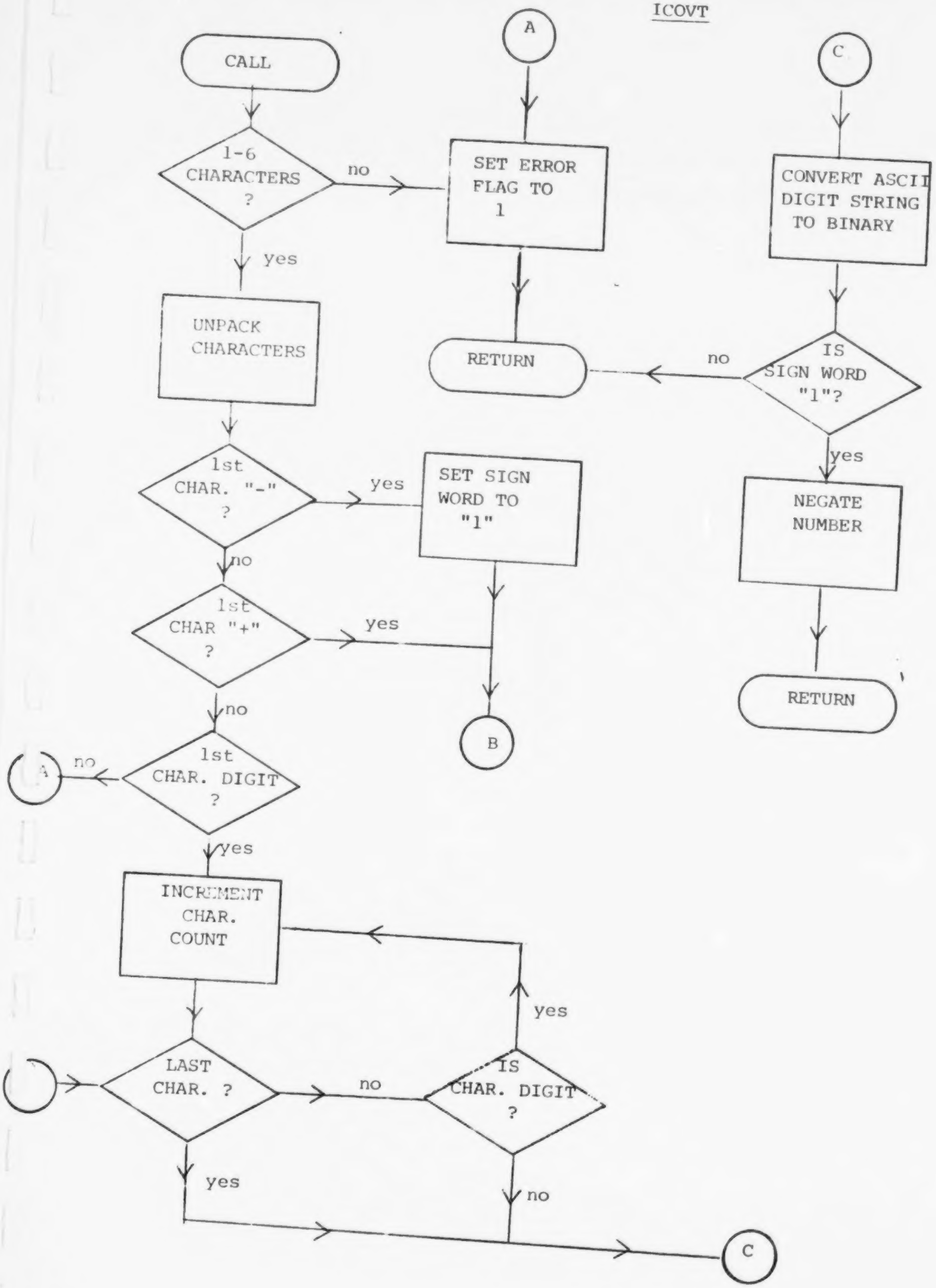
```
CALL  VREAD (NBUFR,3)
```

In this example, up to three characters may be entered via the "teletype". The characters are packed left to right, two characters per computer word in array NBUFR. All unused spaces including the right half of word two are filled with blanks and entries in excess of the designated number of characters are ignored.

VREAD


CALL
FILL BUFFER WITH BLANKS
SET UP PRB
IOQ SUPER. CALL
"←"?
yes
SEND CARRIAGE RETURN
no
"!"?
no
MOVE CHAR. INTO CALL BUFFER
yes
BID DEBUG TASK
RETURN
TERM. TASK

ICOVT


A
CALL
1-6 CHARACTERS ?
no
yes
SET ERROR FLAG TO 1
C
CONVERT ASCII DIGIT STRING TO BINARY
UNPACK CHARACTERS
RETURN
no
IS SIGN WORD "1"?
yes
1st CHAR. "-" ?
yes
SET SIGN WORD TO "1"
NEGATE NUMBER
no
1st CHAR "+" ?
yes
RETURN
no
B
A
no
1st CHAR. DIGIT ?
yes
INCREMENT CHAR. COUNT
yes
LAST CHAR. ?
no
IS CHAR. DIGIT ?
yes
no
C

7.2.7 ICOVT

This PCL callable subroutine is used to convert ASCII digits to integer binary numbers. This subroutine was designed to circumvent the problem with the supplied PCL discussed in section and it was used for both "teletype" and card input.

The subroutine unpacks the character, checks the first digit for plus or minus sign or a digit, checks the remaining characters for digits and converts these characters to binary. The first non-digit terminates the converson. The subroutine call is:

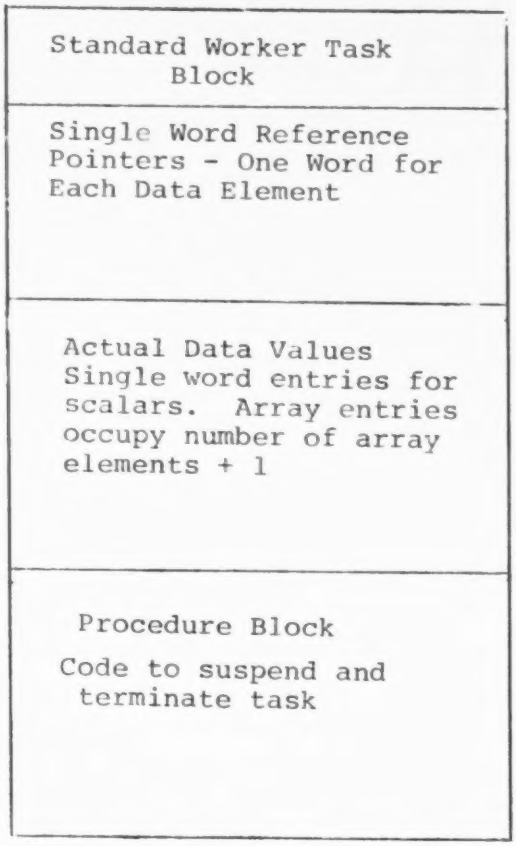
```
CALL  ICOVT  (ARG0, ARG1, ARG2, ARG3)
```

where ARG0 is the packed array containing digits, ARG1 is the number of digits (1-6 allowed), ARG2 is the returned binary number and ARG3 an error flag. This last argument is returned as zero except when ARG1 is outside the allowed number of digits.

7.3 SYSTEM COMMON TASK (ID=26)

System Common (SYS-COM) is a standard PAM/D task which remains inactive throughout system operation. It basically serves as a central location for data storage and inter-task communication. Upon initial entry SYS-COM suspends itself. If it is unsuspended by another task it immediately terminates itself with a normal end-of-program call.

The structure of SYS-COM is given below.



Standard Worker Task Block

Single Word Reference Pointers - One Word for Each Data Element

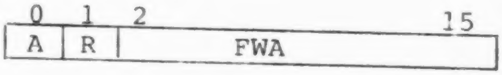
Actual Data Values Single word entries for scalars. Array entries occupy number of array elements + 1

Procedure Block

Code to suspend and terminate task

A description of the Worker Task Blcok can be found in the PAM/D User's Guide.

All data in SYS-COM is referenced through the Reference Pointer Block (RPB). Each RPB entry consists of two flags and a task relative address:



Flag A on indicates data element is an array
off indicates data element is simple variable

Flag R on indicates data element contains floating point values

off indicates integer data.

If both A and R are on, then the data element is considered to be a floating point array.

FWA represents the first word address of the actual data relative to the beginning of SYS-COM.

Actual data is stored following the RPB. The order is not important since the data is always referenced through pointers. However, arrays must be stored contiguously with a true word count heading the array. The count serves to prevent array overflow which could affect many tasks simultaneously.

If the user references SYS-COM through subroutine CDAT exclusively, overflow within SYS-COM is virtually impossible.

Each data element can be uniquely identified by the relative location of its reference pointer within the RPB. For example, "location 1" in System Common is that data element referred to by the first reference pointer word. The first argument of the CDAT subroutine represents the SYS-COM location as just defined.

The following table lists all entries in SYS-COM and how they are interpreted by the rest of the system. All entries are integer.

SYS-COM ENTRIES

REFERENCE POINTER	# OF WORDS ALLOCATED	DATA CHARACTERISTICS	
1	1 word	System Mode Flag	
		Bit on	Meaning
		15	Monitor Mode
		14	Run Mode
		13	Pause Mode
		12	Reset Wind Tunnel Indicator
		0	System halt flag
2	3 words	6 character current test name	
3	1 word	Sort/Log Communication Word	
		Code	Meaning
		1	Sort and print requested data
		2	Read test file header
		3	Begin logging
		0	Returned by S/L to indicate completion of codes 1 and 2
4-7	1 word entries	Unused	
8	1 word	Write Fault Flag	
9	1 word	Elapsed time in minutes from start of wind tunnel	
10	1 word	Startup Communication Word	
			1 System Reset
			2 System Termination
11-22	1 word each	Unused	
23	16 words	Fault override flags	
24	4 words	Last D/A values	
25	5 words	Unused	
26	8 words	Logging Information	
		Word	Meaning
		1	Normal Log Rate (minutes)
		2	Fast Log Rate
		3	Year of last log

SYS-COM ENTRIES (continued)

REFERENCE POINTER	# OF WORDS ALLOCATED	DATA CHARACTERISTICS	
		4	Day of last log
		5	Hour of last log
		6	Min of last log
		7	Second of last log
		8	=1 Norm log =2 Fast log
27	52 words	Wind Tunnel Driver Table	
28	2 words	Active Channel Specifications	
		Word	Meaning
		1	Number of non-std devices
		2	Total Number of define A/D channels
29	3x40 words	Device Name Table For each 3 word entry -	
		Word	Meaning
		1	1'st 2 characters device name
		2	2'nd 2 characters device name
		3	A/D channel number of device
30-37	Each is 6 words	Channel Characteristic Table for channels 0 - 8	
		Word	Meaning
		1	Gain 1 Select Flag
		2	Last value for non-std devices unused for std devices
		3	Engineering Conversion Factor
		4	Lower Span
		5	Upper Span
		6	Calibration Limit
38-69	Each 3 word	Channel Characteristic Table for channels 8 - 39	
		Word	Meaning
		1	Gain and Select Flag
		2	Unused
		3	Engineering Conversion Factor

SYS-COM ENTRIES (continued)

REFERENCE POINTER	# OF WORDS ALLOCATED	DATA CHARACTERISTICS
70	1 word	2 character test file LUNO
71	2 words	Disk Usage Info for Logging Word Meaning 1 Total number os sectors alloc. 2 Total number of sectors used
72	9 words	Contact Closure Settings Lines 0 - 8
73	3 words	Contact Closure Settings Lines 9 - 11
74	2 words	Task Counts Word Meaning 1 Total # of tasks in system 2 Total # of special tasks-not rebid on system reset
75	6 words	List of system tasks

7.4 STARTUP TASK (ID=55)

The Startup task participates in three functions:

1. Load SSDCS system
2. Terminate portions of SSDCD for system RESET
3. Terminate DCS on "END" command

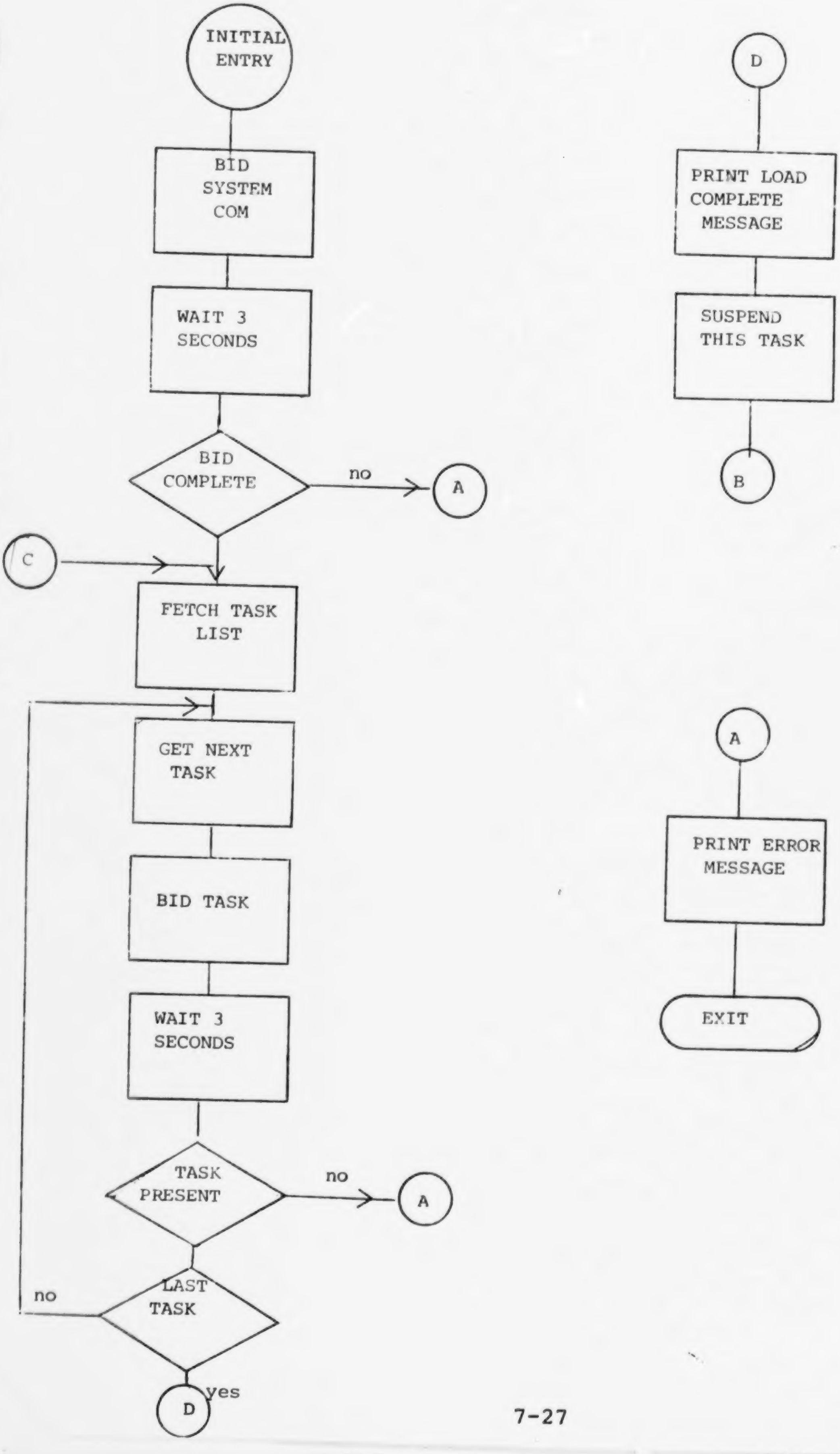
The first function is initiated by the "BIDT 0055" command given by the operator from PAM DEBUG. After Startup has completed its task of loading the system it goes into an unconditional suspend state. The other startup functions are initiated by the Operator Communication Task (OP-COM), OP-COM communicates with startup by storing an operation code at pointer 10_{10} of system common and unsuspending Startup. Startup signals completion of its task by resetting reference location 10 to zero. There is only one difference between the actions taken for functions 2 and 3 above. After Startup acts in behalf of a system reset it goes back to the original suspend state. However, for an END-action command, startup will terminate itself. Otherwise the two functions are identical.

Startup loads system tasks using the PAM BIDT supervisor service routine. After each bid, it goes into a 3 second time delay to allow PAM/D to complete the load. Startup then uses the STA supplied supervisor processor (op-code 8C00) to find the first word address of the task. In this way, startup can test for successful loads.

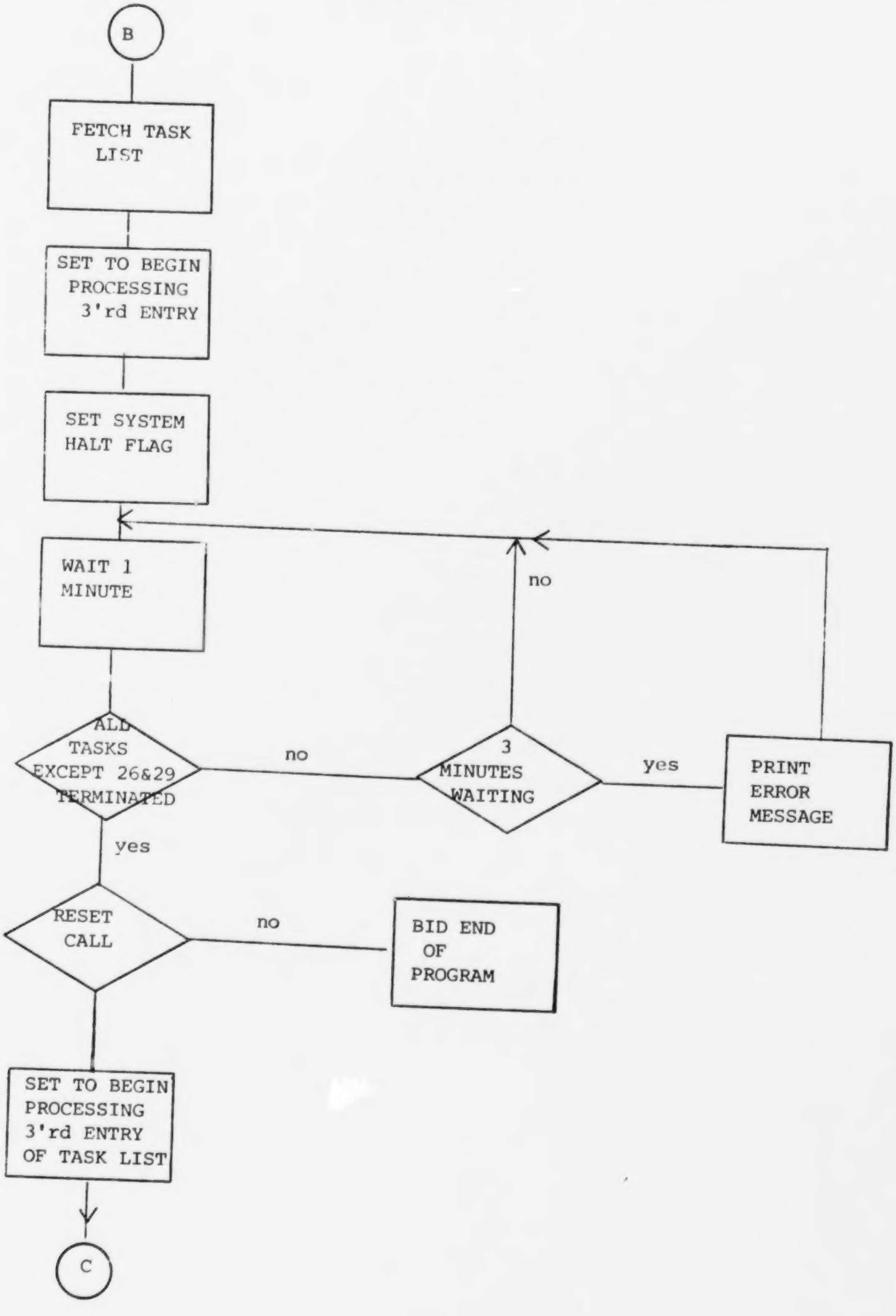
Termination of tasks are checked in the same manner. A task has been terminated if its first word address is returned as zero.

The flowchart for startup follows.

FLOWCHART STARTUP


INITIAL ENTRY
BID SYSTEM COM
WAIT 3 SECONDS
BID COMPLETE
no
A
C
FETCH TASK LIST
GET NEXT TASK
BID TASK
WAIT 3 SECONDS
TASK PRESENT
no
A
LAST TASK
no
yes
D
D
PRINT LOAD COMPLETE MESSAGE
SUSPEND THIS TASK
B
A
PRINT ERROR MESSAGE
EXIT

FLOWCHART STARTUP (continued)


B
FETCH TASK LIST
SET TO BEGIN PROCESSING 3'rd ENTRY
SET SYSTEM HALT FLAG
WAIT 1 MINUTE
ALL TASKS EXCEPT 26&29 TERMINATED
no
3 MINUTES WAITING
no
yes
PRINT ERROR MESSAGE
yes
RESET CALL
no
BID END OF PROGRAM
SET TO BEGIN PROCESSING 3'rd ENTRY OF TASK LIST
C

7.5 OPERATOR COMMUNICATIONS TASK (ID=29)

This task handles all operator communications via "teletype" communications terminal and card reader to the SSDCS system. It consists of a main routine (OPCOM), six (6) resident subroutines, eleven (11) primary overlays, each consisting of one or more subroutines, and three (3) secondary overlays consisting of one subroutine each. The primary overlays are located on disc files D0 and D1 and the secondary overlays are on files CA and CB. Details of messages and operator input are described in the DCS Operator's Manual.

7.5.1 DESCRIPTION OF OPCOM

Whenever TASK 29 is bid an asterisk (*) is typed and the task is suspended by a "teletype" input request (IOQ, supervisor call). Upon termination of an entry with a carriage return the first two characters of the input are compared to twenty-two (22) possible commands and the required operation is performed. If the command is illegal for any reason an appropriate message is typed. After each function has been performed except "END", the system returns to the IOQ supervisor call. An "END" command causes all seven resident tasks of DCS to be terminated.

7.5.2 STATUS COMMANDS

There are six (6) commands that modify system status, OPER, PAUS, CONT, RSET, END and RWDT. The normal operating modes are monitor (1), operate (2) and pause (4). Monitor and operator are mutually exclusive. The system's initial status is 5 (monitor and pause).

7.5.3 COMMAND "OPER"

This command sets the system status to "2" and the log flag to "3". The significance of the log flag is discussed in section 7.8.

7.5.4 COMMAND "PAUS"

This command turns on bit 13 of the status word by doing a logical "or" of the current status with "4".

7.5.5 COMMAND "CONT"

This command turns off bit 13 of the status word via a logical "and".

7.5.6 COMMAND "RSET"

This command turns off bit 13 of the status word, all status control words and all words in the fault override array. It then unsuspends the Startup task, checks in 10-second intervals whether tasks 21, 27, 28 and 35 have been terminated and rebid, and returns to the IOQ supervisor call.

7.5.7 COMMAND "END"

7.5.8 COMMAND "RWDT"

This command turns on bit 12 of the status word and returns to the IOQ supervisor call. Bit 12 is tirned off in Task 28 prior to suspending that task.

7.5.9 LOGGING RATE COMMANDS

There are two logging rate commands, NORM and FAST. These commands set the eighth word in the System Common log array to "1" and "2", respectively.

7.5.10 BACKPURGE

Backpurge is initiated by command "BACK" and is valid in all modes. The command casues loading of overlay "2" from files D0 and D1, activates the backpurge solenoid, checks on two 5-second intervals whether the filter is plugged, types "Plugged Filter" if contact closure is on after two passes and deactivates the backpurge solenoid.

7.5.11 ZERO CALIBRATION

Zero calibration is initiated by command "ZERO" and is accepted in the "pause" mode. Overlay "3" form files D0 and D1 is loaded; the backpurge and zero calibration solenoids are activated; zero calibration of O_2, SO_2, CO, CO_2 and NOX are checked after a 5-minute delay; messages are typed if any of the instruments is out-of-calibration; and the two solenoids are deactivated.

7.5.12 SPAN CALIBRATION

Span calibration is initiated by command "SPAN" and is accepted in the "pause" mode. Overlay "4" from files D0 and D1 is loaded; the backpurge solenoid is activated; and the operator is requested to designate an instrument. Upon entering either 0_2, SO_2, CO, CO_2 or NOX, the corresponding standard gas solenoid is activated and after a 5-minute delay a new calibration slope is calibrated. Both solenoids are then deactivated and the system returns to the IOQ supervisor call.

7.5.13 STARTING WIND TUNNEL

Command "SWDT" unsuspends Task 28 and is valid in any mode.

7.5.14 TIME AND DATE UPDATE

Command "TIME" permits operator update of time and date from the "teletype" communications terminal and is valid in the "pause" mode. When this command is entered, overlay "5" from files D0 and D1 is loaded, the year, Julian day, hour, and minutes are requested from the operator and the entered time is typed upon completion of all entries.

7.5.15 FAULT OVERRIDE

The command "FOVR" is used to turn off a fault message even though the fault (one of a set of contact closures) is still on. This command is accepted in all modes. First, overlay 6 from files D0 and D1 is loaded. The operator then may override sixteen (16) of the eighteen (18) fault messages. Upon termination with an ampresand (&), the fault override array is written to system common and the designated messages are overridden.

7.5.16 INITIALIZING WIND TUNNEL PARAMETERS

The command "IWDT" permits specification of wind tunnel parameters during the monitor mode. This command loads overlay 7 from files D0 and D1. Operator input may be accepted from either the "teletype" (subroutine IWDT) or the card reader (subroutine CIWDT). The Wind Tunnel Driver Table built during this interface consists of a fifty-two (52) word array consisting of up to twelve time entries and a terminator (X'4C20') and integer values for temperature, velocity and humidity corresponding to the designated times. Details on the operator interface and card format are in the SSDCS Operator's Manual.

7.5.17 SELECTION OF INSTRUMENTS

The command "SELE" may be used to select the instruments when the system is in the pause mode. This command loads overlay "8" from files D0 and D1 and allows the operator to specify instruments via either the "teletype" terminal (subroutine SELE) or card reader (subroutine CSELE). Permanent instruments are always resident in the instrument list and may be specified during either monitor or operate modes. Auxillary instruments must be designated under "monitor" mode, but may be deactivated or reactivated during "operate" mode. Card input is limited to the "monitor" mode. When an instrument is taken "off line", 100 is added to its gain which is the first word in that instruments A/D Characteristics Table. Details of operator interface and card format are in the SSDCS Operator's Manual.

7.5.18 PARAMETER DESIGNATION

Parameters may be designated by the command "PSET" during the pause mode. This command loads overlay 9 from files D0 and D1. Upon initial entry the operator has four options. He may request to specify logging rates (LOG), specify card reader (CDR), specify a particular instrument, or specify a dump to the line printer of current parameters (DUMP). Card reader input and specific instrument designation are valid only in the "monitor" mode.

7.5.19 LOGGING RATE

Modificaton to the logging rate by "teletype" is controlled by subroutine PSET and does not require a secondary overlay. The system will accept integer logging rates and a fast logging rate at a shorter interval than the normal rate.

7.5.20 CARD INPUT

When card input is requested, secondary overlay "1" from files CA and CB is loaded. This overlay (subroutine CPSET) sets the logging rates and instrument parameters as specified in the SSDCS Operator's Manual. A card inproperly placed in the deck terminates input and an appropriate message is typed.

7.5.21 PRINTING INSTRUMENT PARAMETERS

When a "DUMP" is specified overlay "2" from files CA and CB is loaded. This overlay, subroutine DPSET, prints the logging rates, instrument status and instrument parameters.

7.5.22 SPECIFYING INSTRUMENT PARAMETER VIA "TELETYPE"

Whenever an operator entry is not recognized by subroutine PSET (the primary overlay), secondary overlay "3" frm files CA and CB is loaded. This overlay, containing subroutine LPSET, compares the entry with the list of instruments. Upon identification of this instrument, the required parameters for the instrument are requested. Details of this interface are in the Operator's Manual. If the instrument is either absent from the list or off line an appropriate message is typed.

7.5.23 DUMP COMMANDS

7.5.24 SORT COMMAND

Command "SORT" loads overlay X'B' from files D0 and D1 and is valid in the "pause" mode. This overlay (subroutine SORTC) communicates thru the sort common word in system common task with the sort/log task. After TASK 35 notifies this subroutine that the data is ready to be printed, the name of the test is typed and up to five instruments may be specified. Each instrument designation is compared to the instrument list and when a match is made a 100. is added to the channel designation following the name. When either five instruments or an "L" have been entered the subroutine terminates and the sort/log task prints the requested data. Details of communication between tasks are found in section .

7.5.25 COMMAND STAT

STAT provides for a neatly formatted printer dump of current A/D, last D/A and all contact closure readings.

This command is processed by overlay B of the OP-COM overlay file. It is the only overlay with an argument. The overlay consists of two routines - DUMP and CHDP. Execution of the STAT command involves the following call:

```
CALL DUMP(1)
```

7.5.26 COMMAND DWDT

DWDT provides a printer dump of the currently configured Wind Tunnel Parameter Table. It uses the same overlay as STAT and is executed with

```
CALL DUMP(2)
```

7.5.27 COMMAND DPIN

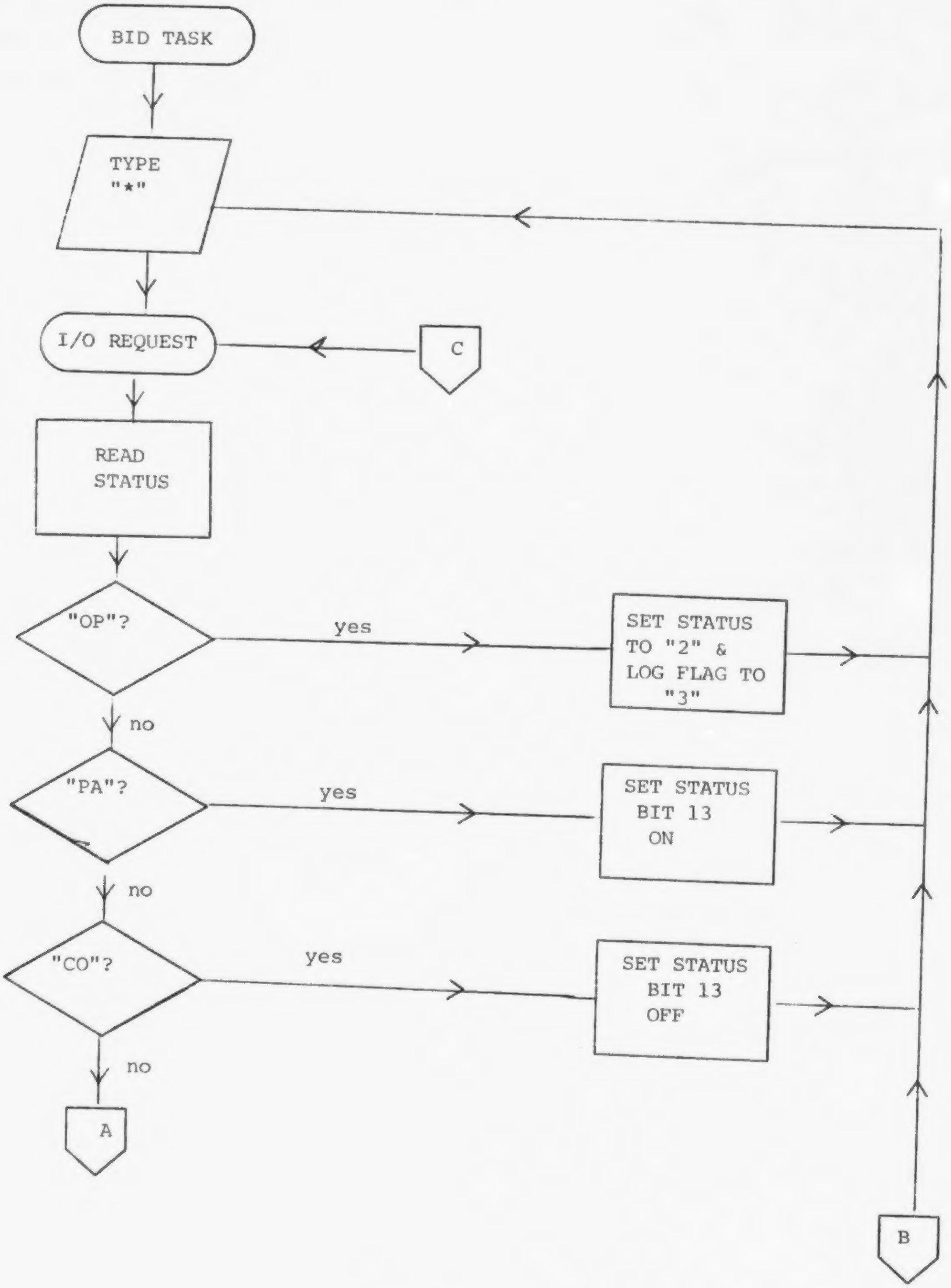
DPIN dumps the current engineering values of all instruments defined to the system. This command is also processed through DUMP.

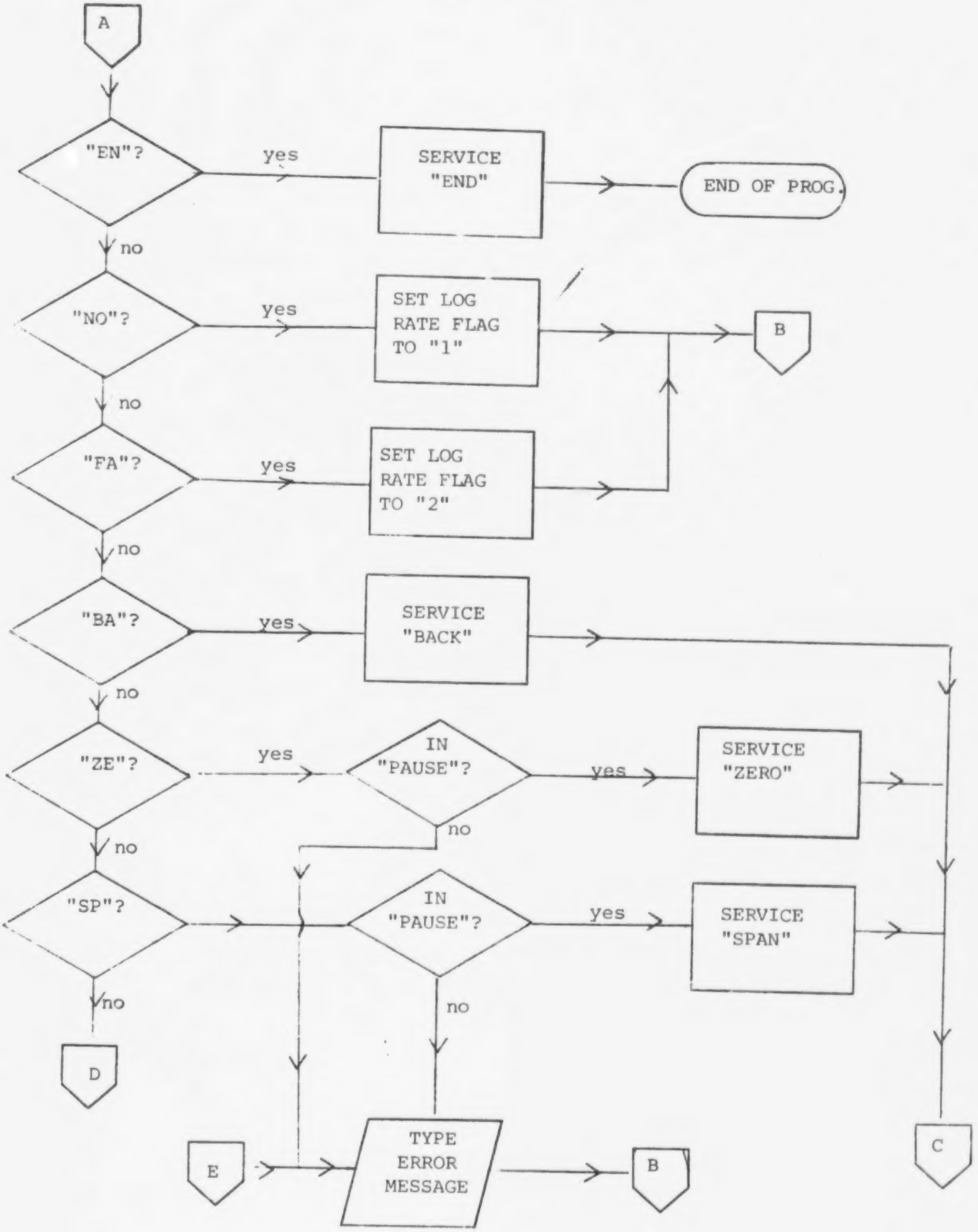
```
CALL DUMP(3)
```

7.5.28 COMMAND DISC

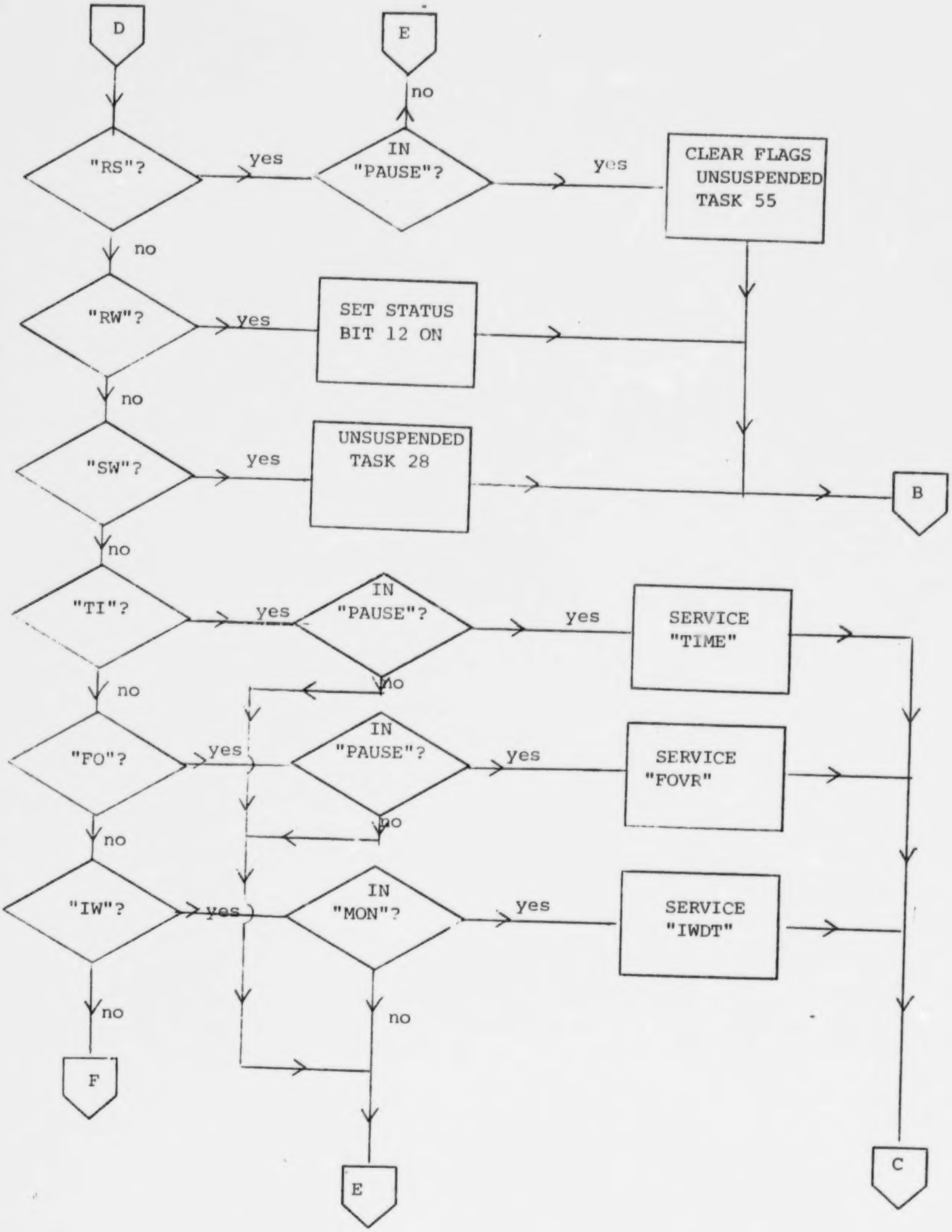
DISC provides information on the amount of space still available in the test file. It is executed from OP-COM thru

```
CALL DUMP(4)
```

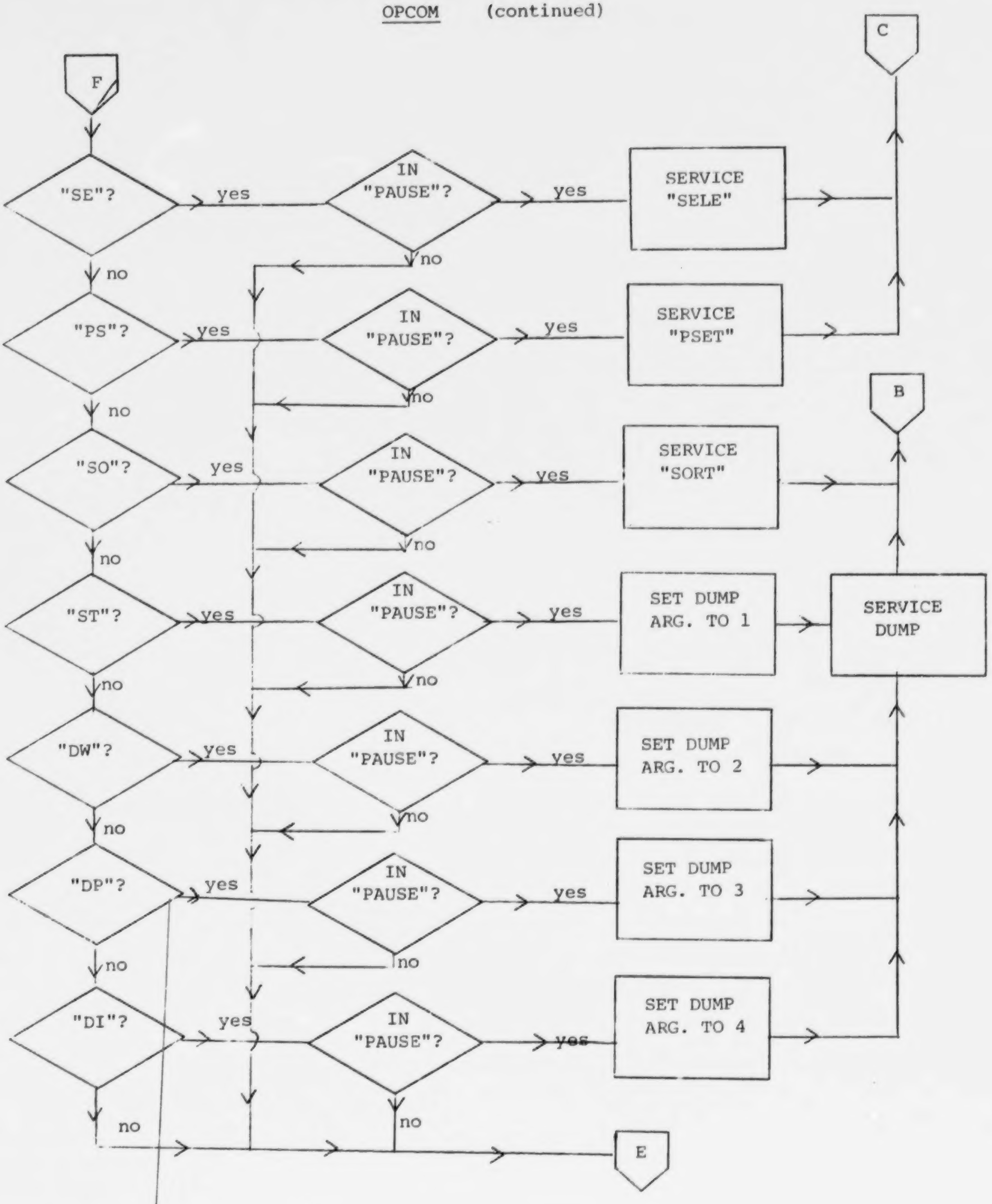

BID TASK
TYPE "*"
I/O REQUEST
C
READ STATUS
"OP"?
yes
SET STATUS TO "2" & LOG FLAG TO "3"
no
"PA"?
yes
SET STATUS BIT 13 ON
no
"CO"?
yes
SET STATUS BIT 13 OFF
no
A
B


A
"EN"?
yes
SERVICE "END"
END OF PROG.
no
"NO"?
yes
SET LOG RATE FLAG TO "1"
B
no
"FA"?
yes
SET LOG RATE FLAG TO "2"
no
"BA"?
yes
SERVICE "BACK"
no
"ZE"?
yes
IN "PAUSE"?
yes
SERVICE "ZERO"
no
no
"SP"?
IN "PAUSE"?
yes
SERVICE "SPAN"
no
no
D
E
TYPE ERROR MESSAGE
B
C

OPCOM (continued)

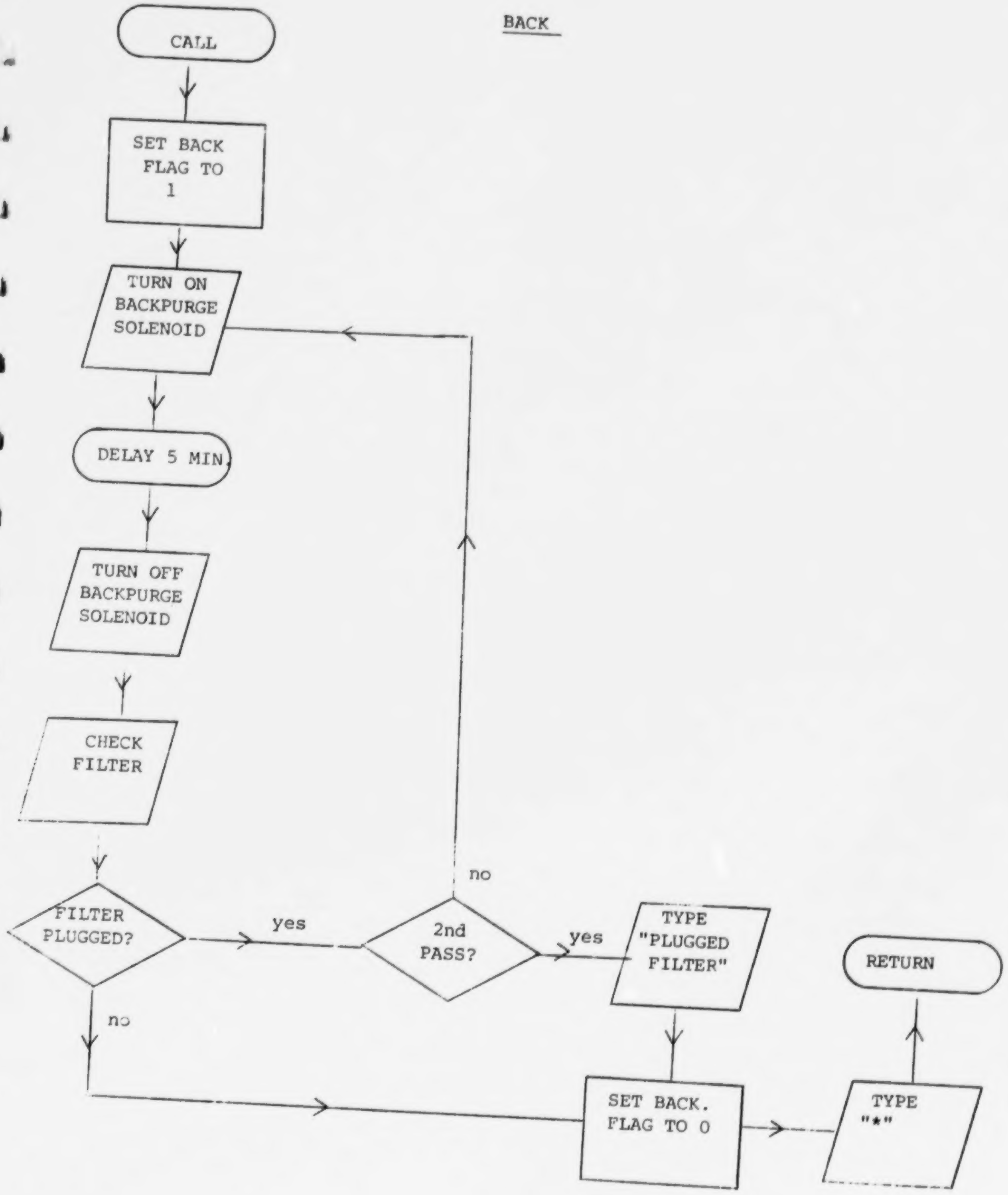

D
E
no
"RS"?
yes
IN "PAUSE"?
yes
CLEAR FLAGS UNSUSPENDED TASK 55
no
"RW"?
yes
SET STATUS BIT 12 ON
no
"SW"?
yes
UNSUSPENDED TASK 28
B
no
"TI"?
yes
IN "PAUSE"?
yes
SERVICE "TIME"
no
no
"FO"?
yes
IN "PAUSE"?
yes
SERVICE "FOVR"
no
no
"IW"?
yes
IN "MON"?
yes
SERVICE "IWDT"
no
no
F
E
C

OPCOM (continued)

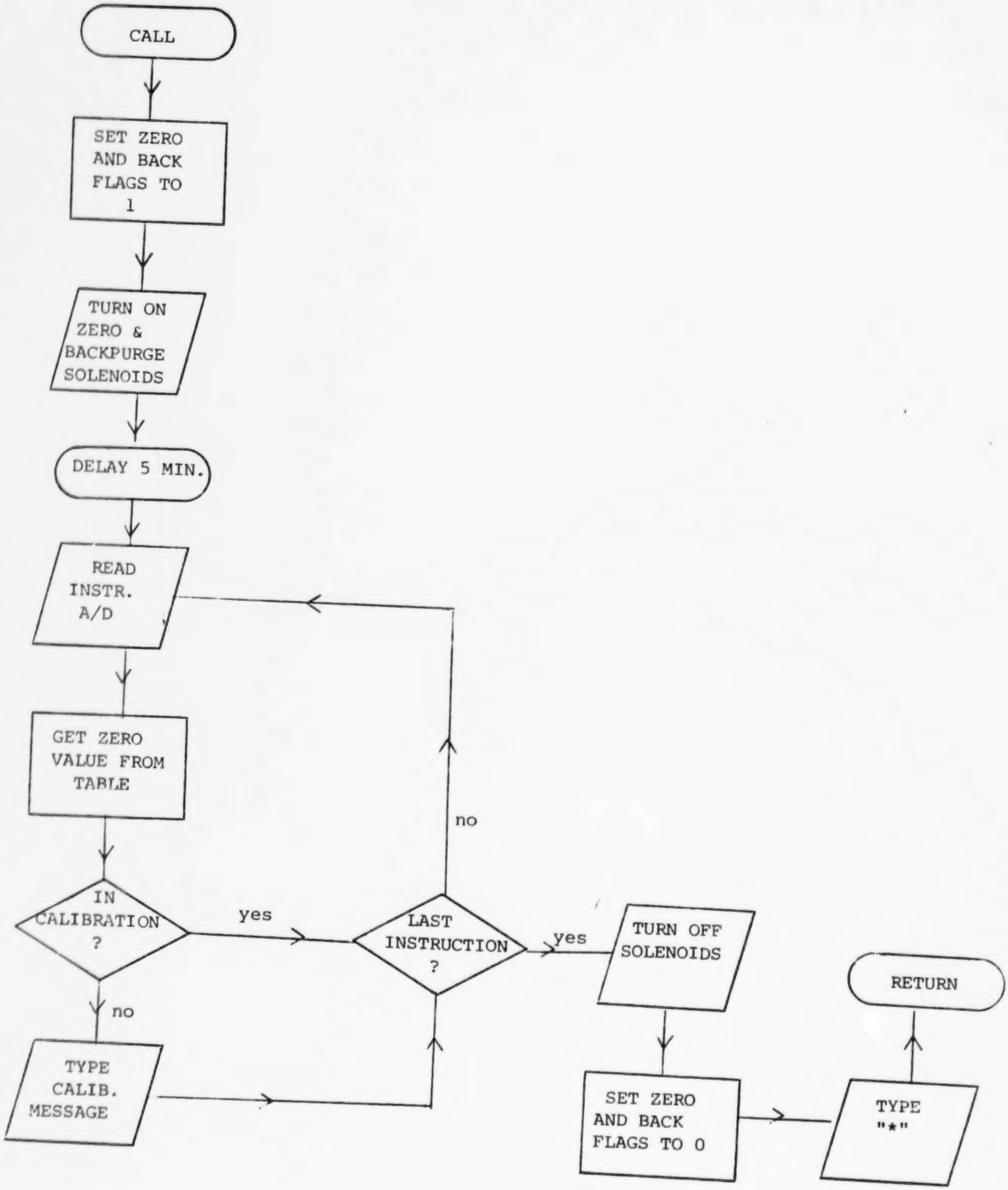


F
"SE"?
yes
IN "PAUSE"?
yes
SERVICE "SELE"
no
C
no
"PS"?
yes
IN "PAUSE"?
yes
SERVICE "PSET"
no
no
B
"SO"?
yes
IN "PAUSE"?
yes
SERVICE "SORT"
no
no
"ST"?
yes
IN "PAUSE"?
yes
SET DUMP ARG. TO 1
SERVICE DUMP
no
no
"DW"?
yes
IN "PAUSE"?
yes
SET DUMP ARG. TO 2
no
no
"DP"?
yes
IN "PAUSE"?
yes
SET DUMP ARG. TO 3
no
no
"DI"?
yes
IN "PAUSE"?
yes
SET DUMP ARG. TO 4
no
no
E

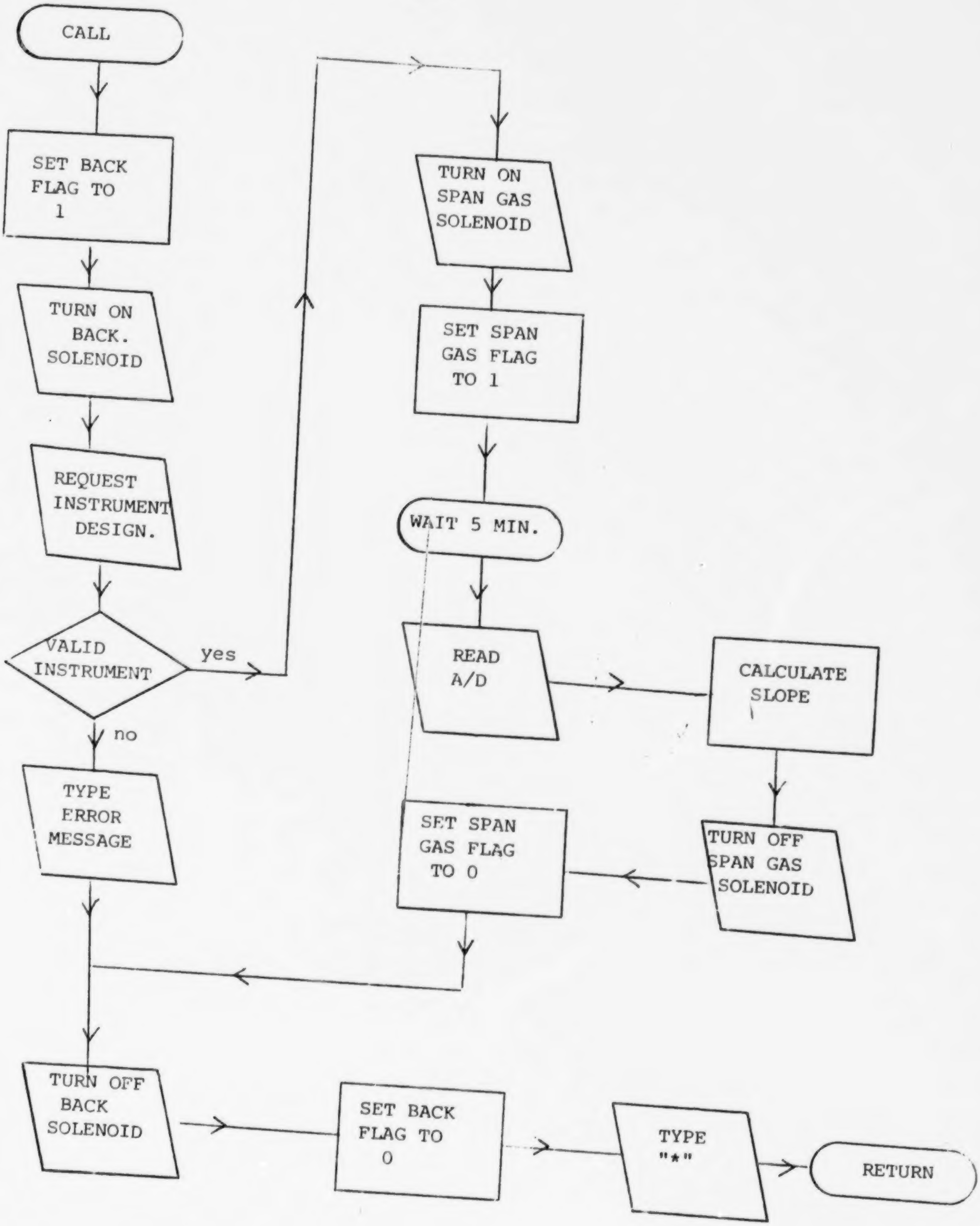
BACK


CALL
SET BACK FLAG TO 1
TURN ON BACKPURGE SOLENOID
DELAY 5 MIN.
TURN OFF BACKPURGE SOLENOID
CHECK FILTER
FILTER PLUGGED?
yes
no
2nd PASS?
no
yes
TYPE "PLUGGED FILTER"
SET BACK. FLAG TO 0
TYPE "*"
RETURN

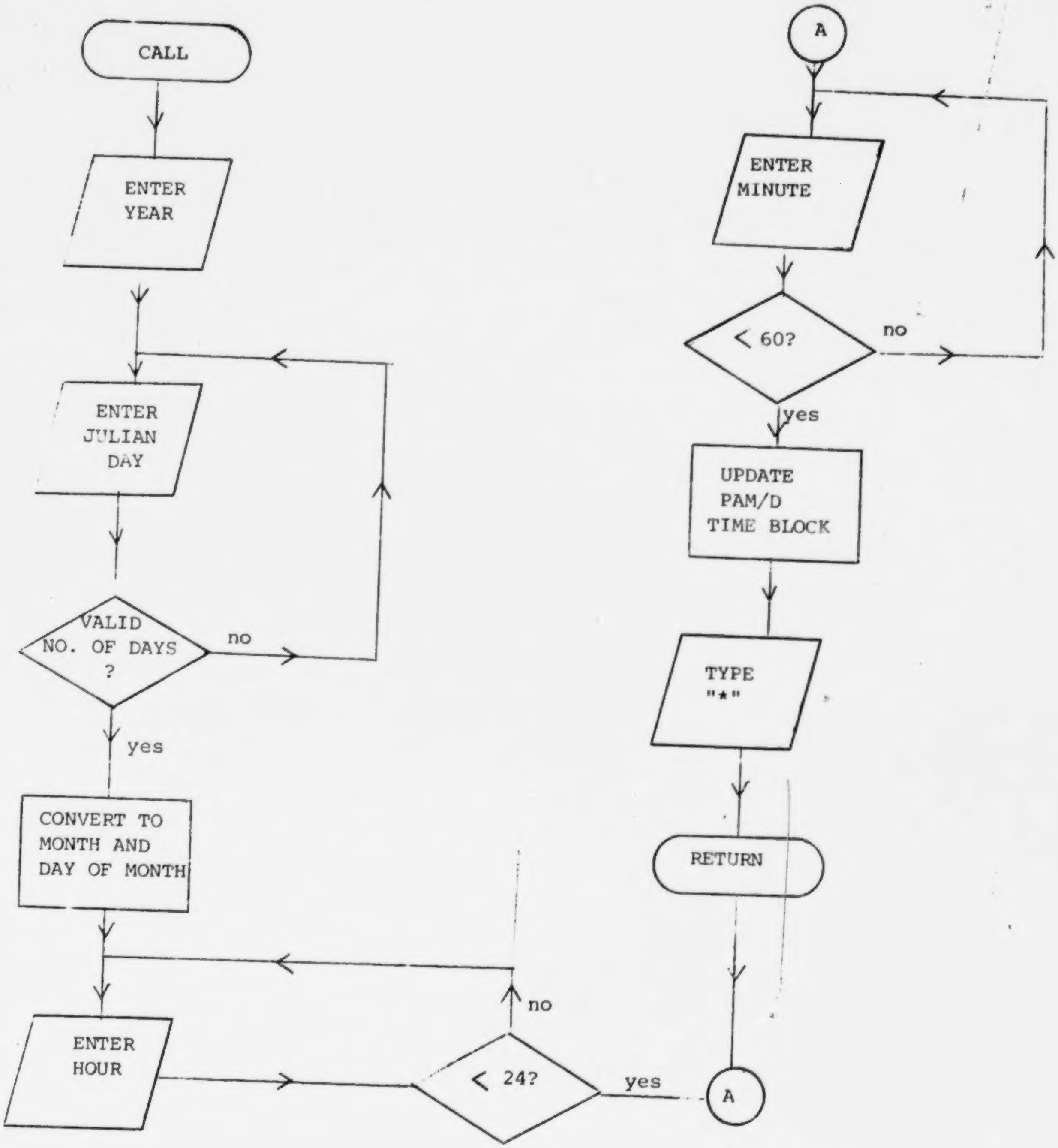
ZERO


CALL
SET ZERO AND BACK FLAGS TO 1
TURN ON ZERO & BACKPURGE SOLENOIDS
DELAY 5 MIN.
READ INSTR. A/D
GET ZERO VALUE FROM TABLE
IN CALIBRATION ?
yes
no
TYPE CALIB. MESSAGE
LAST INSTRUCTION ?
no
yes
TURN OFF SOLENOIDS
SET ZERO AND BACK FLAGS TO 0
TYPE "*"
RETURN

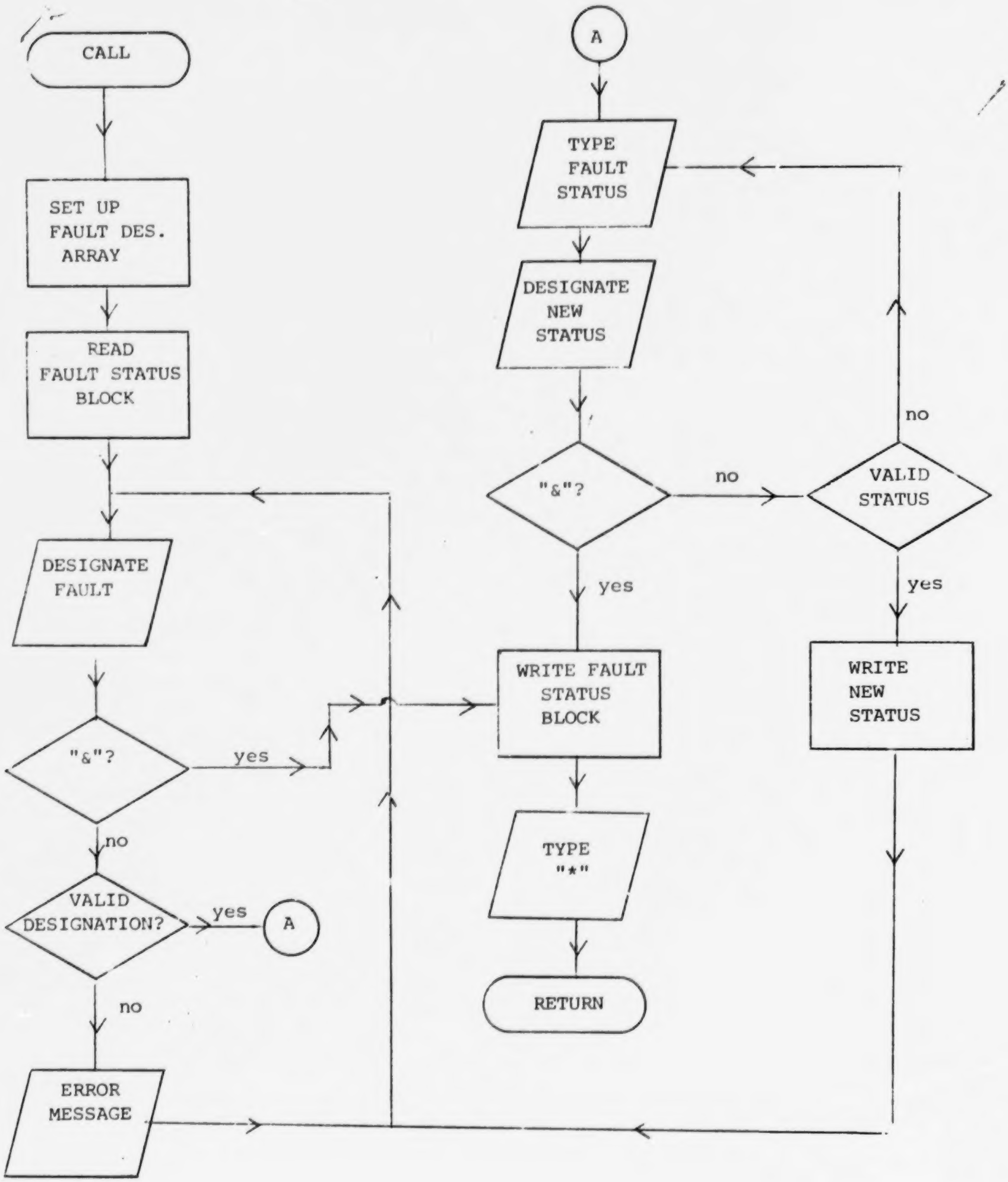
SPAN


CALL
SET BACK FLAG TO 1
TURN ON BACK. SOLENOID
REQUEST INSTRUMENT DESIGN.
VALID INSTRUMENT
yes
no
TYPE ERROR MESSAGE
TURN ON SPAN GAS SOLENOID
SET SPAN GAS FLAG TO 1
WAIT 5 MIN.
READ A/D
CALCULATE SLOPE
TURN OFF SPAN GAS SOLENOID
SET SPAN GAS FLAG TO 0
TURN OFF BACK SOLENOID
SET BACK FLAG TO 0
TYPE "*"
RETURN

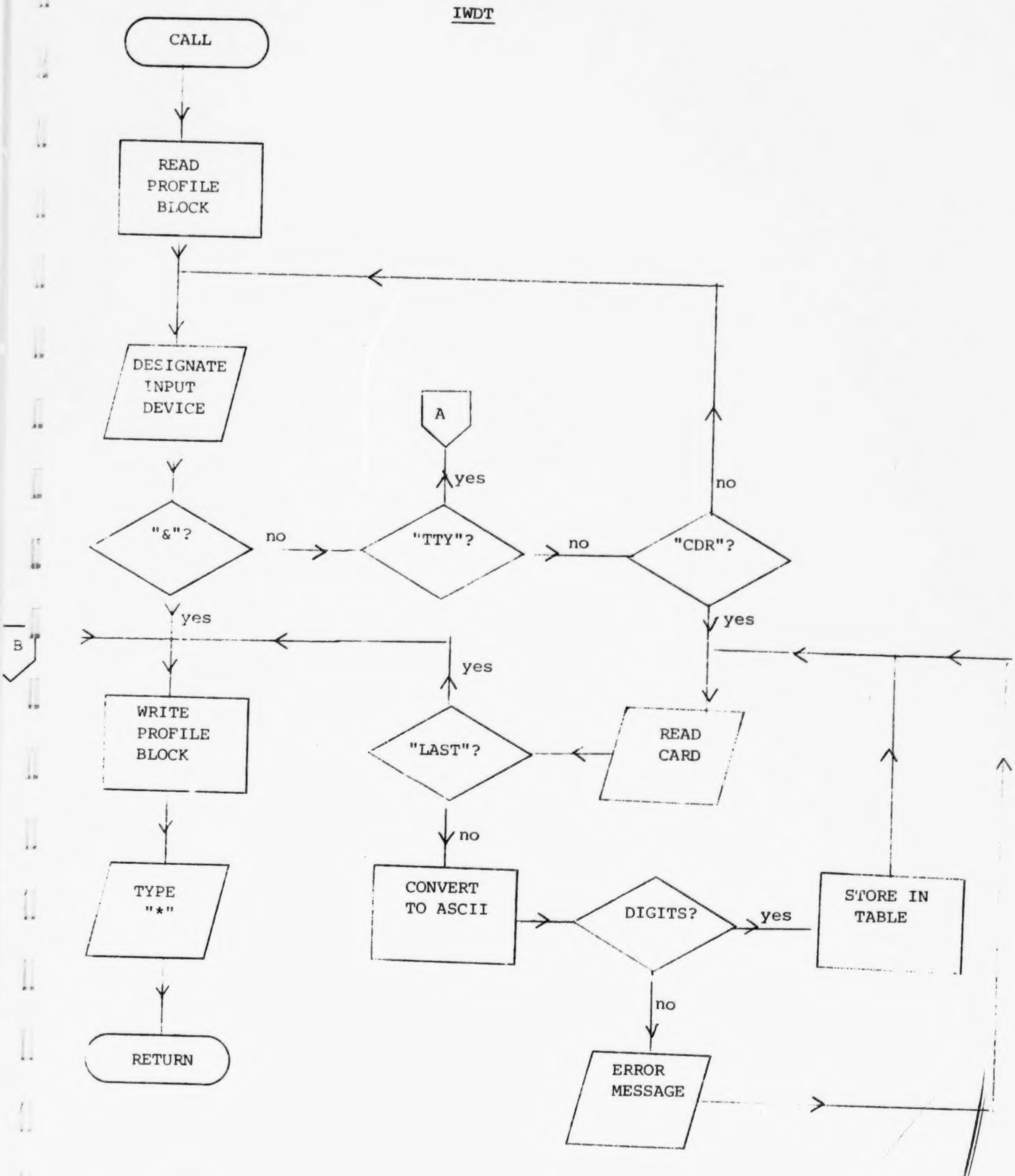
TIME


CALL
ENTER YEAR
ENTER JULIAN DAY
VALID NO. OF DAYS ?
no
yes
CONVERT TO MONTH AND DAY OF MONTH
ENTER HOUR
< 24?
no
yes
A
A
ENTER MINUTE
< 60?
no
yes
UPDATE PAM/D TIME BLOCK
TYPE "*"
RETURN

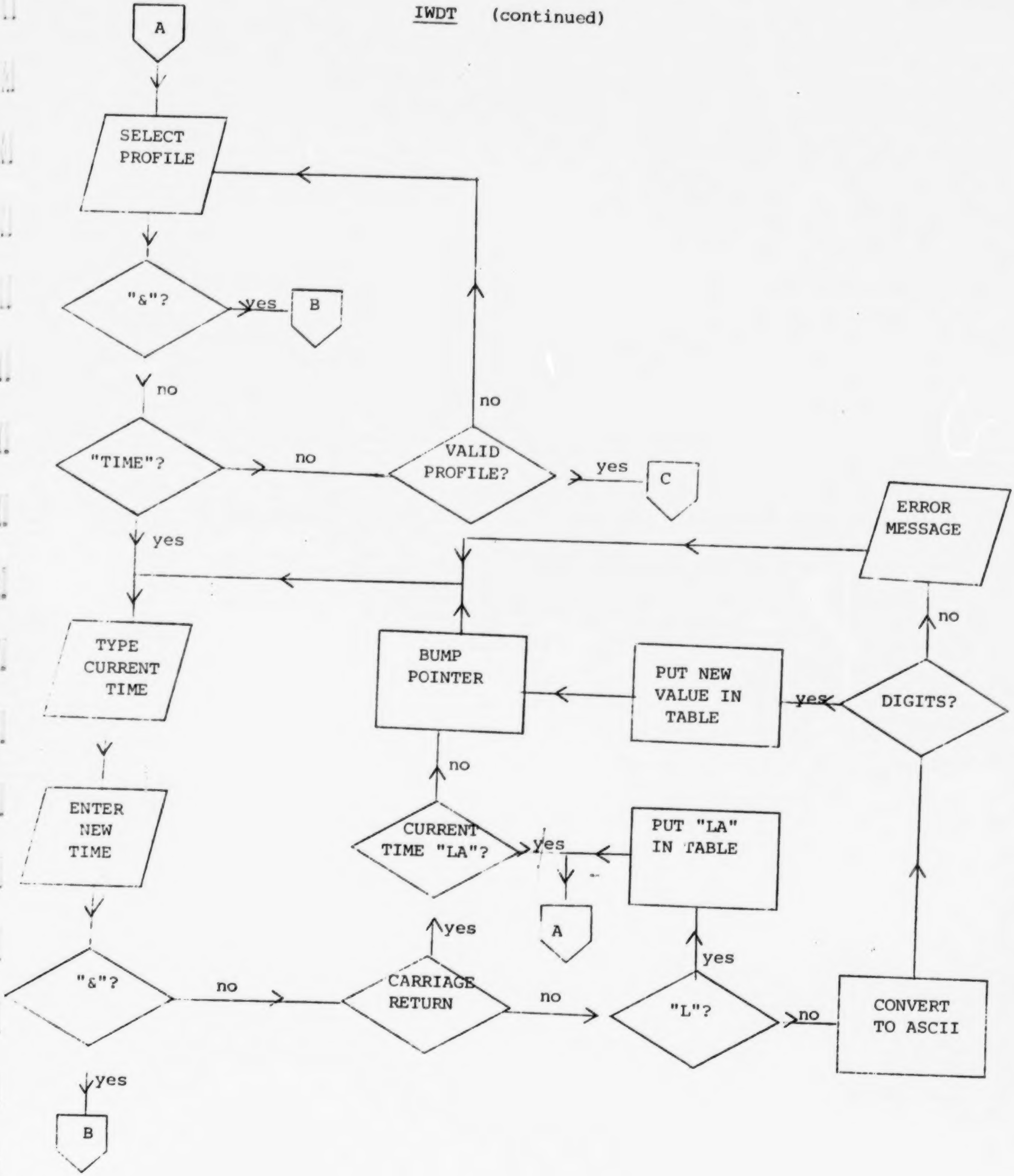
FOVR


CALL
SET UP FAULT DES. ARRAY
READ FAULT STATUS BLOCK
DESIGNATE FAULT
"&"?
yes
no
VALID DESIGNATION?
yes
A
no
ERROR MESSAGE
A
TYPE FAULT STATUS
DESIGNATE NEW STATUS
"&"?
no
yes
VALID STATUS
no
yes
WRITE FAULT STATUS BLOCK
WRITE NEW STATUS
TYPE "*"
RETURN

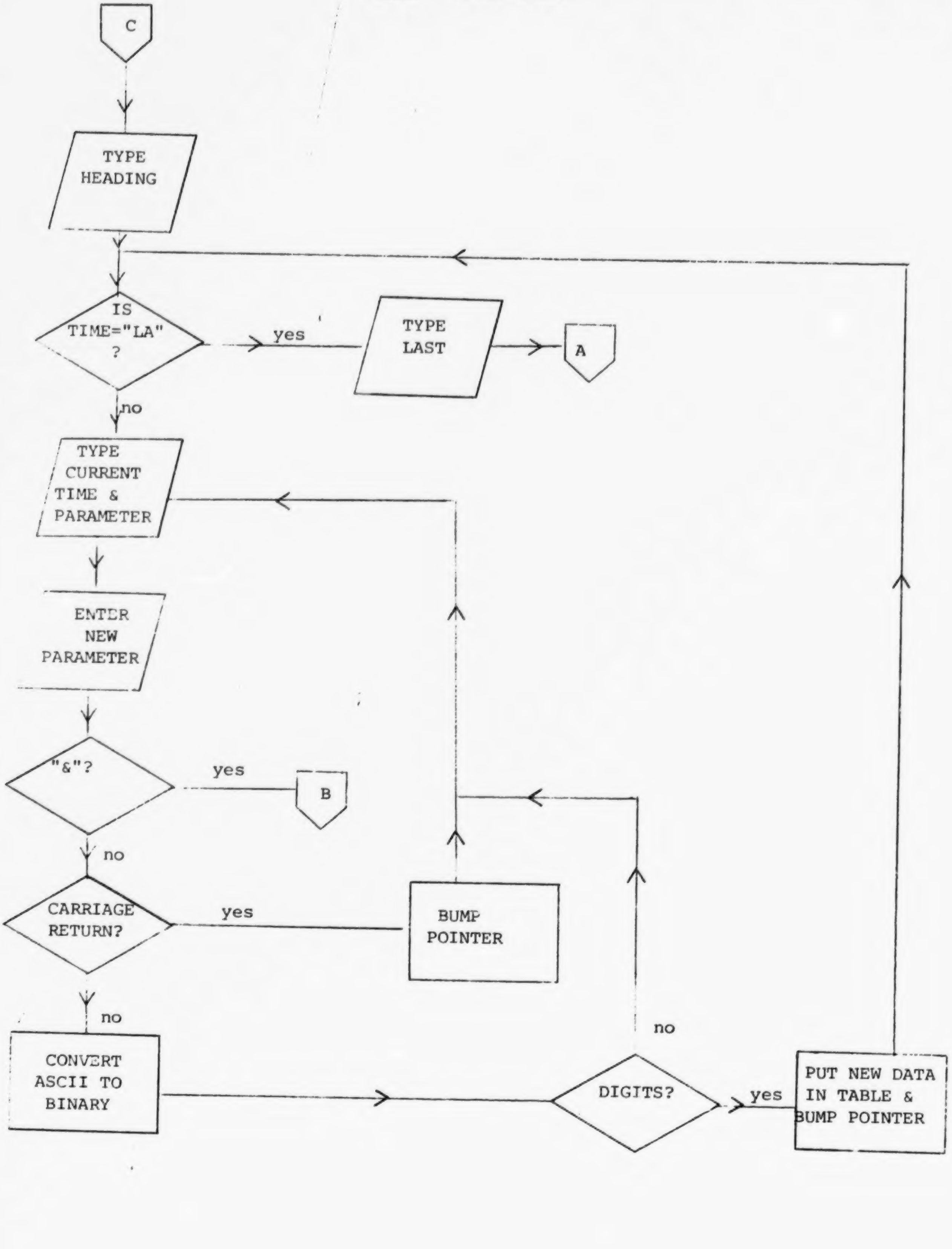
IWDT

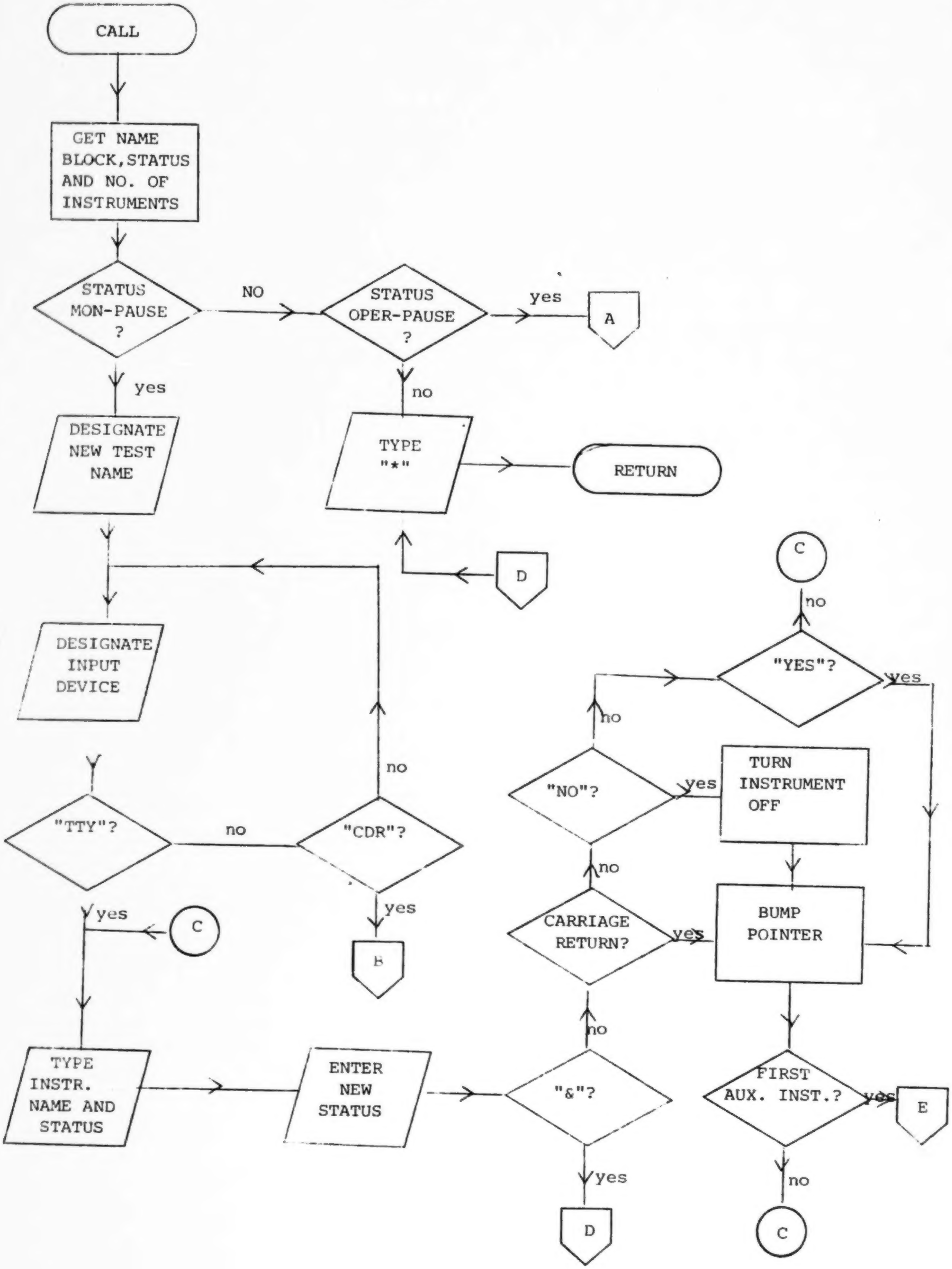

CALL
READ PROFILE BLOCK
DESIGNATE INPUT DEVICE
"&"?
no
"TTY"?
yes
A
no
"CDR"?
no
yes
B
yes
WRITE PROFILE BLOCK
yes
"LAST"?
READ CARD
no
TYPE "*"
CONVERT TO ASCII
DIGITS?
yes
STORE IN TABLE
no
RETURN
ERROR MESSAGE

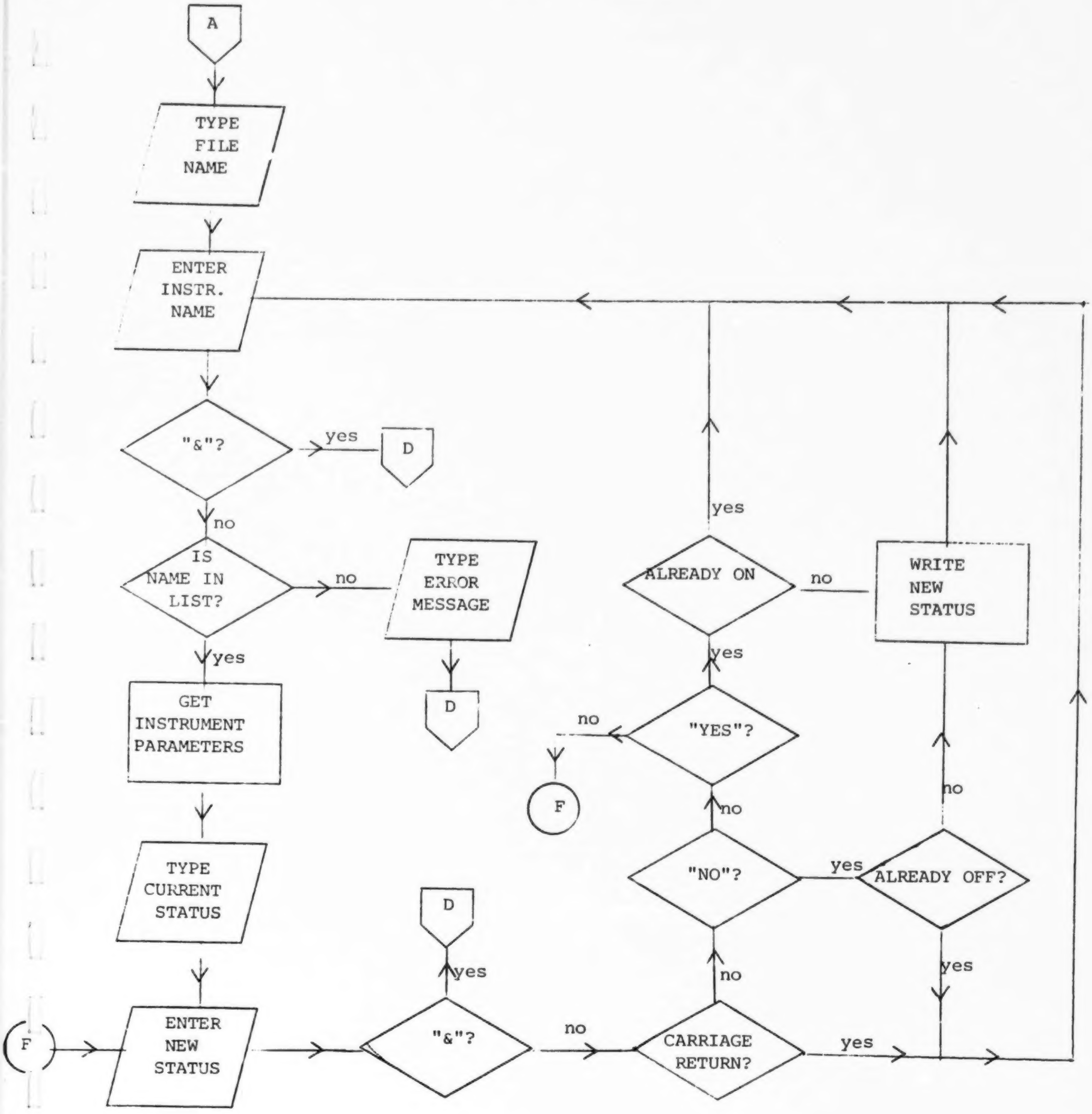
IWDT (continued)


A
SELECT PROFILE
"&"?
yes
B
no
"TIME"?
no
VALID PROFILE?
no
yes
C
yes
ERROR MESSAGE
no
TYPE CURRENT TIME
BUMP POINTER
PUT NEW VALUE IN TABLE
yes
DIGITS?
ENTER NEW TIME
no
CURRENT TIME "LA"?
yes
PUT "LA" IN TABLE
A
yes
"&"?
no
CARRIAGE RETURN
no
"L"?
no
CONVERT TO ASCII
yes
yes
B

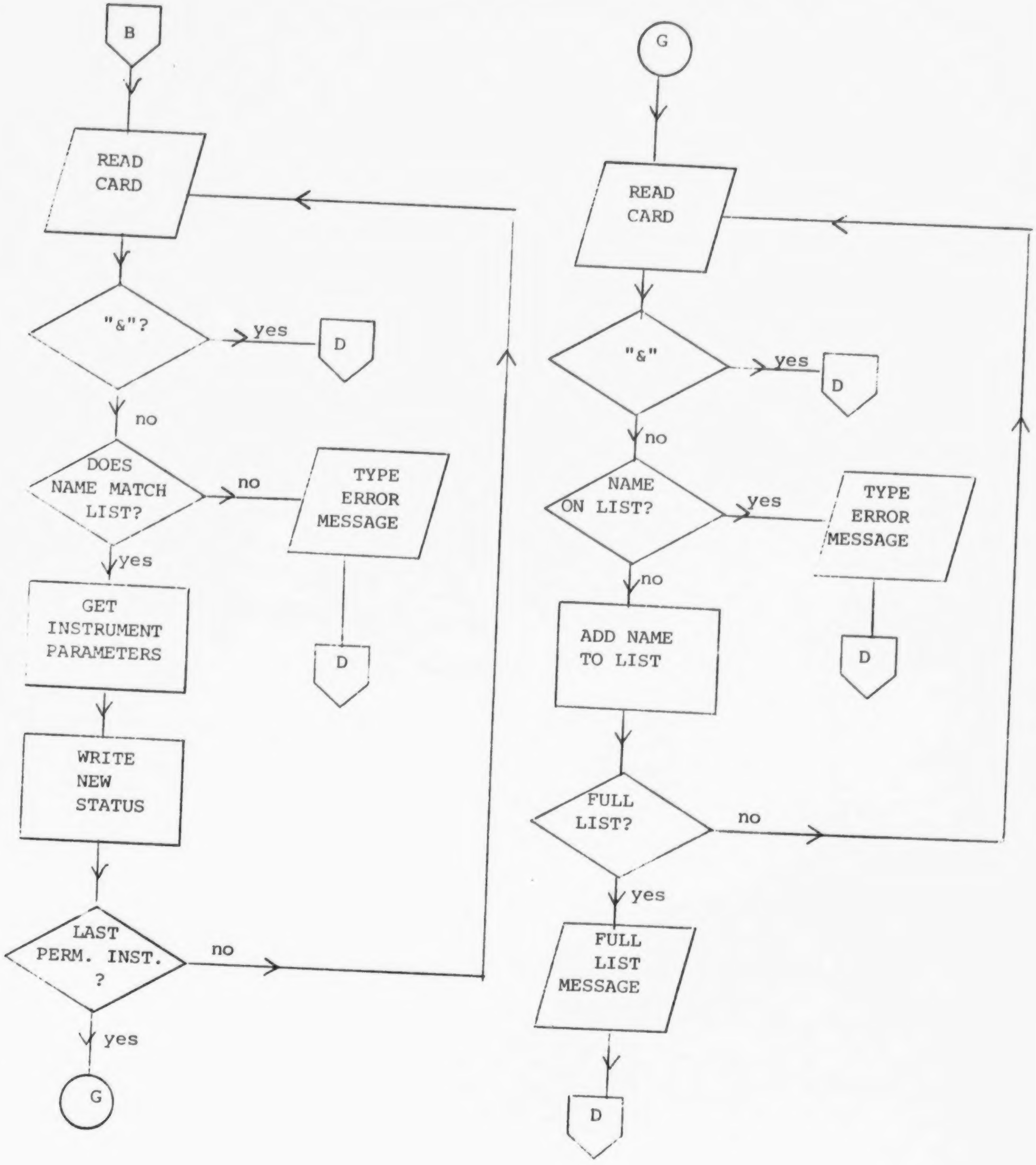
IWDT (continued)

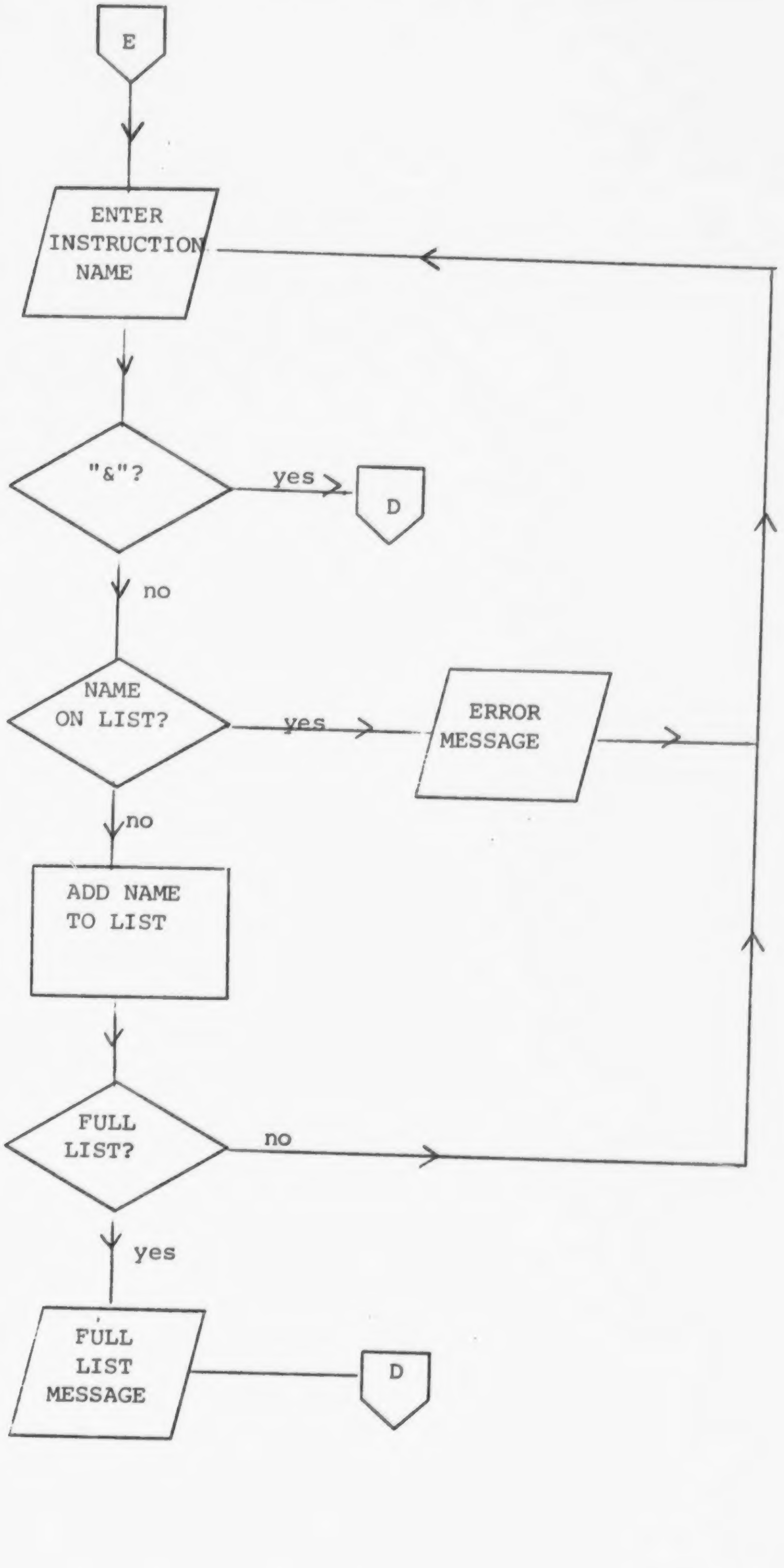

C
TYPE HEADING
IS TIME="LA" ?
yes
TYPE LAST
A
no
TYPE CURRENT TIME & PARAMETER
ENTER NEW PARAMETER
"&"?
yes
B
no
CARRIAGE RETURN?
yes
BUMP POINTER
no
CONVERT ASCII TO BINARY
DIGITS?
no
yes
PUT NEW DATA IN TABLE & BUMP POINTER


CALL
GET NAME BLOCK, STATUS AND NO. OF INSTRUMENTS
STATUS MON-PAUSE ?
NO
STATUS OPER-PAUSE ?
yes
A
yes
no
DESIGNATE NEW TEST NAME
TYPE "*"
RETURN
D
C
no
DESIGNATE INPUT DEVICE
"YES"?
yes
no
"NO"?
yes
TURN INSTRUMENT OFF
no
"TTY"?
no
"CDR"?
yes
CARRIAGE RETURN?
yes
BUMP POINTER
yes
C
B
no
TYPE INSTR. NAME AND STATUS
ENTER NEW STATUS
"&"?
FIRST AUX. INST.?
yes
E
yes
no
D
C

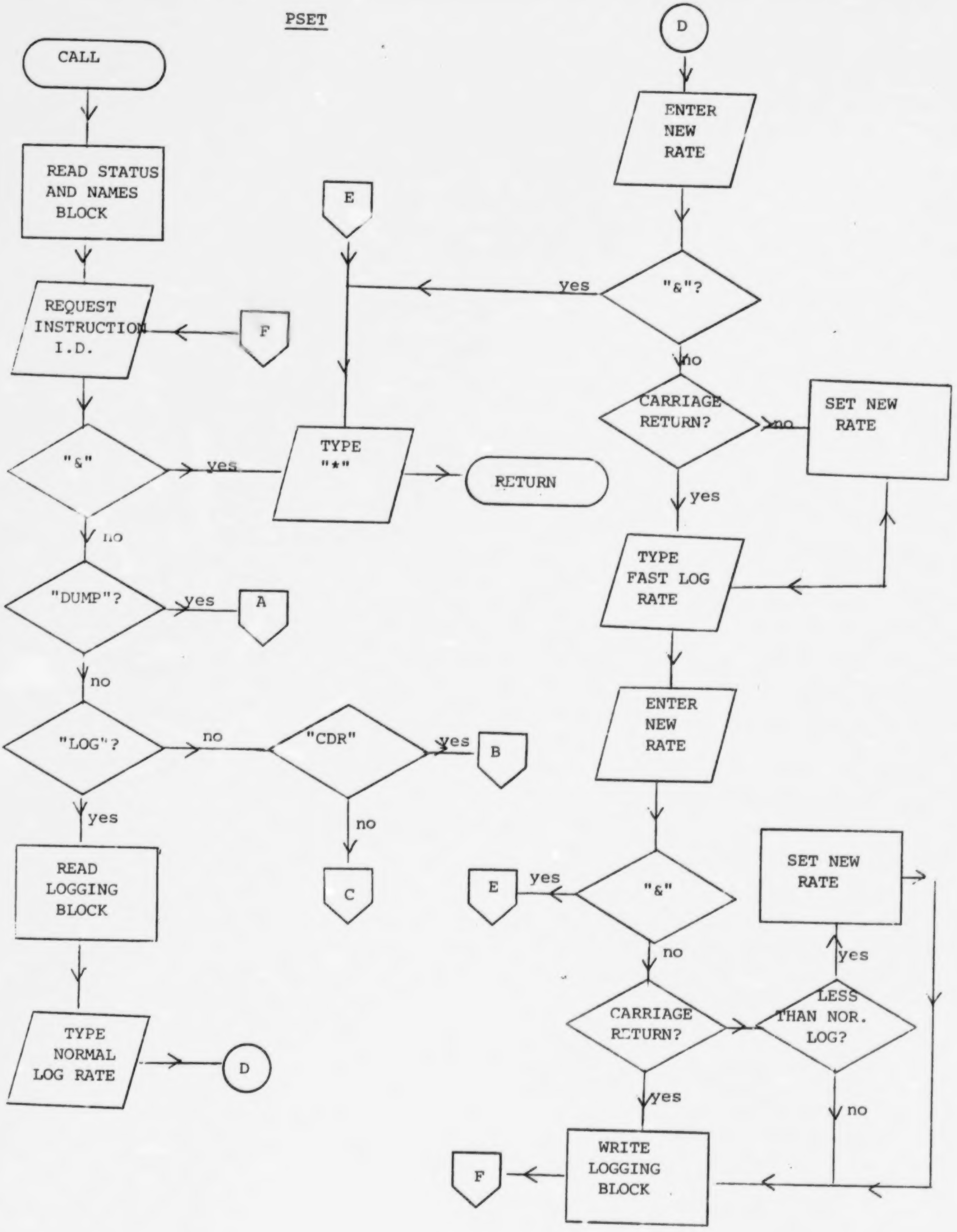

A
TYPE FILE NAME
ENTER INSTR. NAME
"&"?
yes
D
no
IS NAME IN LIST?
no
TYPE ERROR MESSAGE
D
yes
GET INSTRUMENT PARAMETERS
TYPE CURRENT STATUS
F
ENTER NEW STATUS
D
yes
"&"?
no
CARRIAGE RETURN?
yes
no
"NO"?
yes
ALREADY OFF?
yes
no
no
"YES"?
no
F
yes
ALREADY ON
no
yes
WRITE NEW STATUS

SELE (continued)

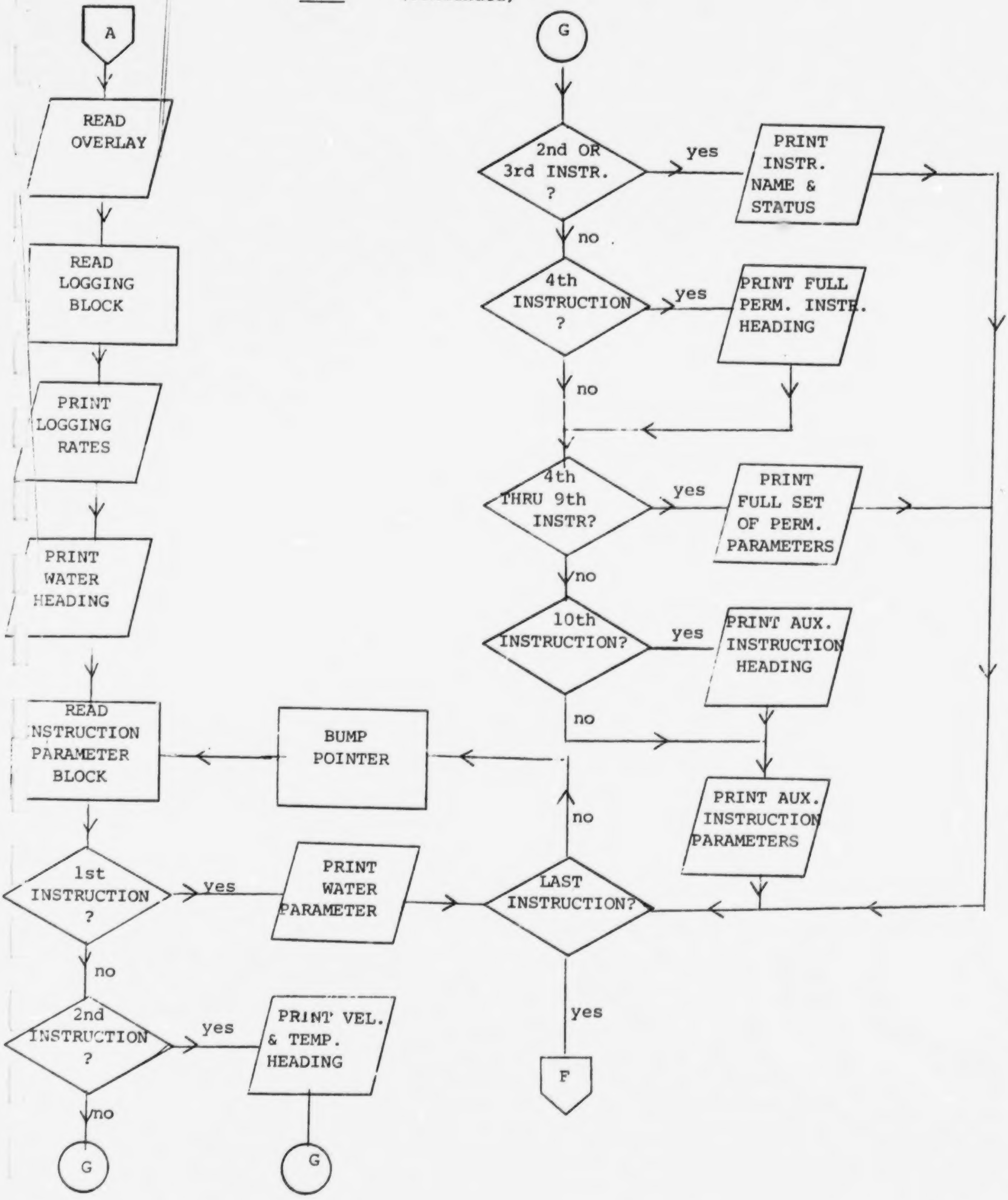

B
READ CARD
"&"?
yes
D
no
DOES NAME MATCH LIST?
no
TYPE ERROR MESSAGE
D
yes
GET INSTRUMENT PARAMETERS
WRITE NEW STATUS
LAST PERM. INST. ?
no
yes
G
G
READ CARD
"&"
yes
D
no
NAME ON LIST?
yes
TYPE ERROR MESSAGE
D
no
ADD NAME TO LIST
FULL LIST?
no
yes
FULL LIST MESSAGE
D


E
ENTER INSTRUCTION NAME
"&"?
yes
D
no
NAME ON LIST?
yes
ERROR MESSAGE
no
ADD NAME TO LIST
FULL LIST?
no
yes
FULL LIST MESSAGE
D

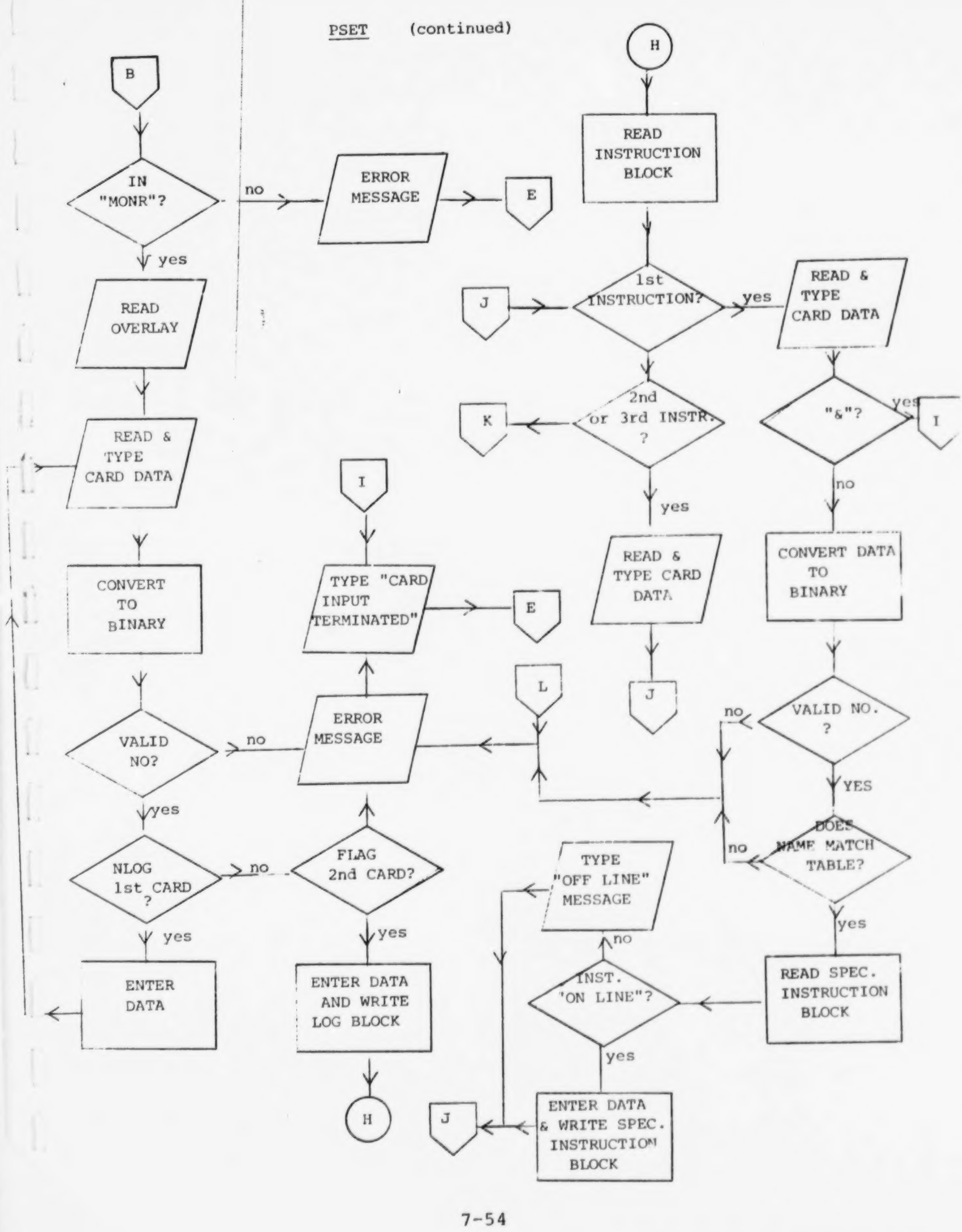
PSET


CALL
READ STATUS AND NAMES BLOCK
REQUEST INSTRUCTION I.D.
F
"&"
yes
TYPE "*"
RETURN
E
no
"DUMP"?
yes
A
no
"LOG"?
no
"CDR"
yes
B
no
C
yes
READ LOGGING BLOCK
TYPE NORMAL LOG RATE
D
D
ENTER NEW RATE
"&"?
yes
no
CARRIAGE RETURN?
no
SET NEW RATE
yes
TYPE FAST LOG RATE
ENTER NEW RATE
"&"
yes
E
no
CARRIAGE RETURN?
LESS THAN NOR. LOG?
yes
SET NEW RATE
no
yes
WRITE LOGGING BLOCK
F

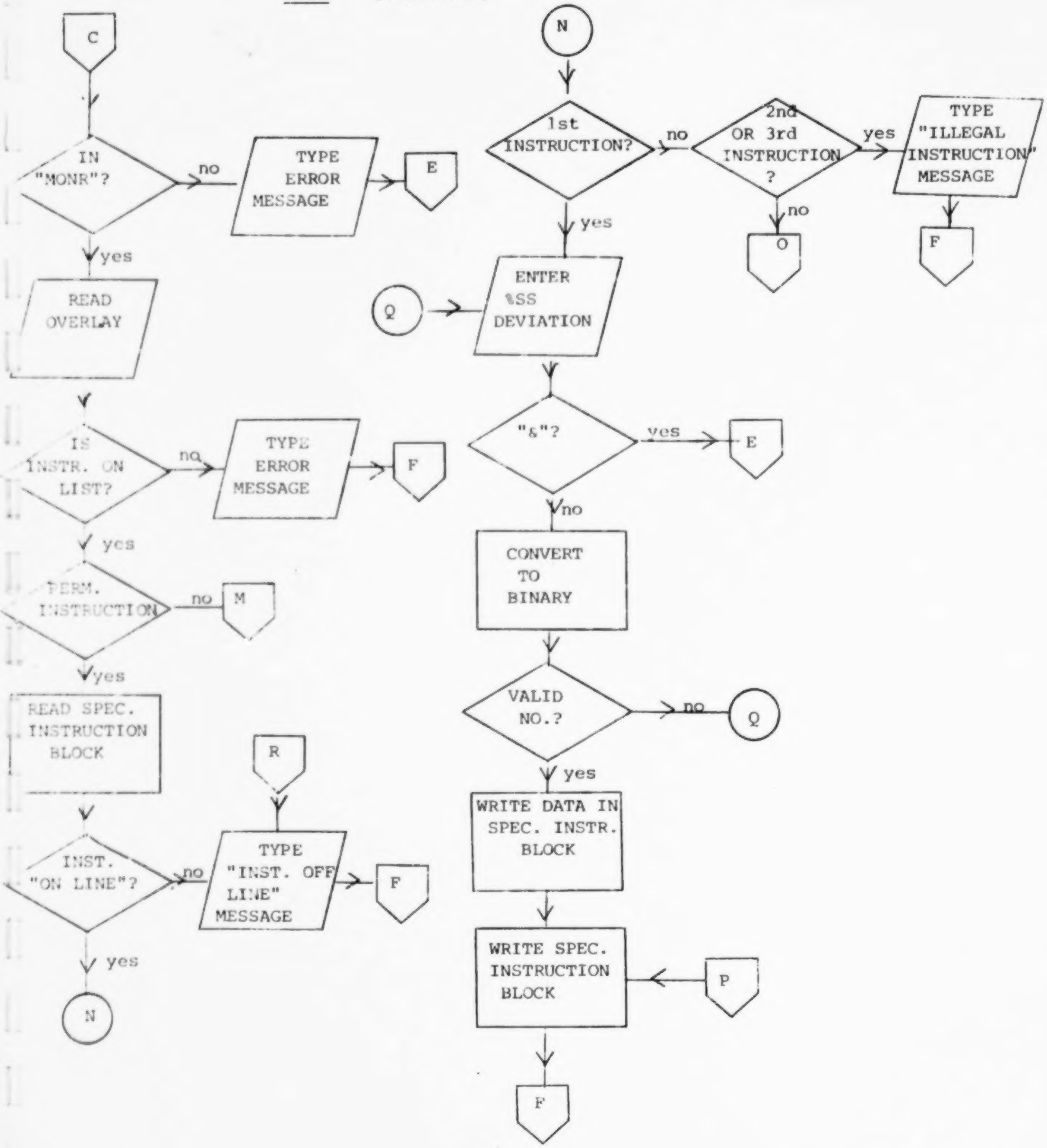
PSET (continued)


A
READ OVERLAY
READ LOGGING BLOCK
PRINT LOGGING RATES
PRINT WATER HEADING
READ INSTRUCTION PARAMETER BLOCK
1st INSTRUCTION ?
yes
PRINT WATER PARAMETER
no
2nd INSTRUCTION ?
yes
PRINT VEL. & TEMP. HEADING
no
G
G
BUMP POINTER
G
2nd OR 3rd INSTR. ?
yes
PRINT INSTR. NAME & STATUS
no
4th INSTRUCTION ?
yes
PRINT FULL PERM. INSTR. HEADING
no
4th THRU 9th INSTR?
yes
PRINT FULL SET OF PERM. PARAMETERS
no
10th INSTRUCTION?
yes
PRINT AUX. INSTRUCTION HEADING
no
PRINT AUX. INSTRUCTION PARAMETERS
LAST INSTRUCTION?
no
yes
F

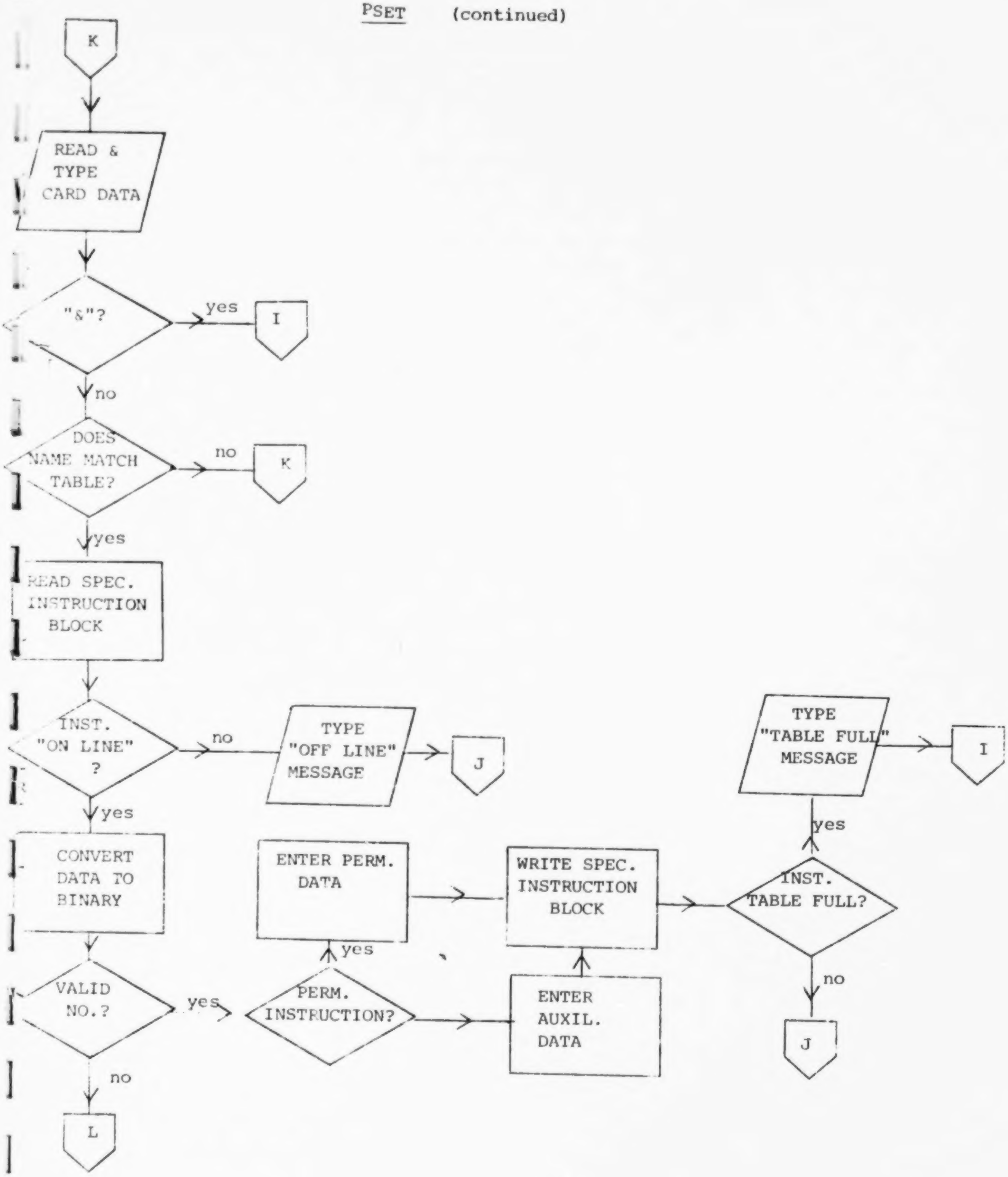
PSET (continued)


B
IN "MONR"?
no
ERROR MESSAGE
E
yes
READ OVERLAY
READ & TYPE CARD DATA
CONVERT TO BINARY
VALID NO?
no
yes
NLOG 1st CARD ?
no
yes
ENTER DATA
I
TYPE "CARD INPUT TERMINATED"
E
ERROR MESSAGE
FLAG 2nd CARD?
yes
ENTER DATA AND WRITE LOG BLOCK
H
H
READ INSTRUCTION BLOCK
J
1st INSTRUCTION?
yes
READ & TYPE CARD DATA
K
2nd or 3rd INSTR. ?
yes
READ & TYPE CARD DATA
J
L
"&"?
yes
I
no
CONVERT DATA TO BINARY
VALID NO. ?
no
YES
DOES NAME MATCH TABLE?
no
yes
READ SPEC. INSTRUCTION BLOCK
INST. "ON LINE"?
no
TYPE "OFF LINE" MESSAGE
yes
ENTER DATA & WRITE SPEC. INSTRUCTION BLOCK
J

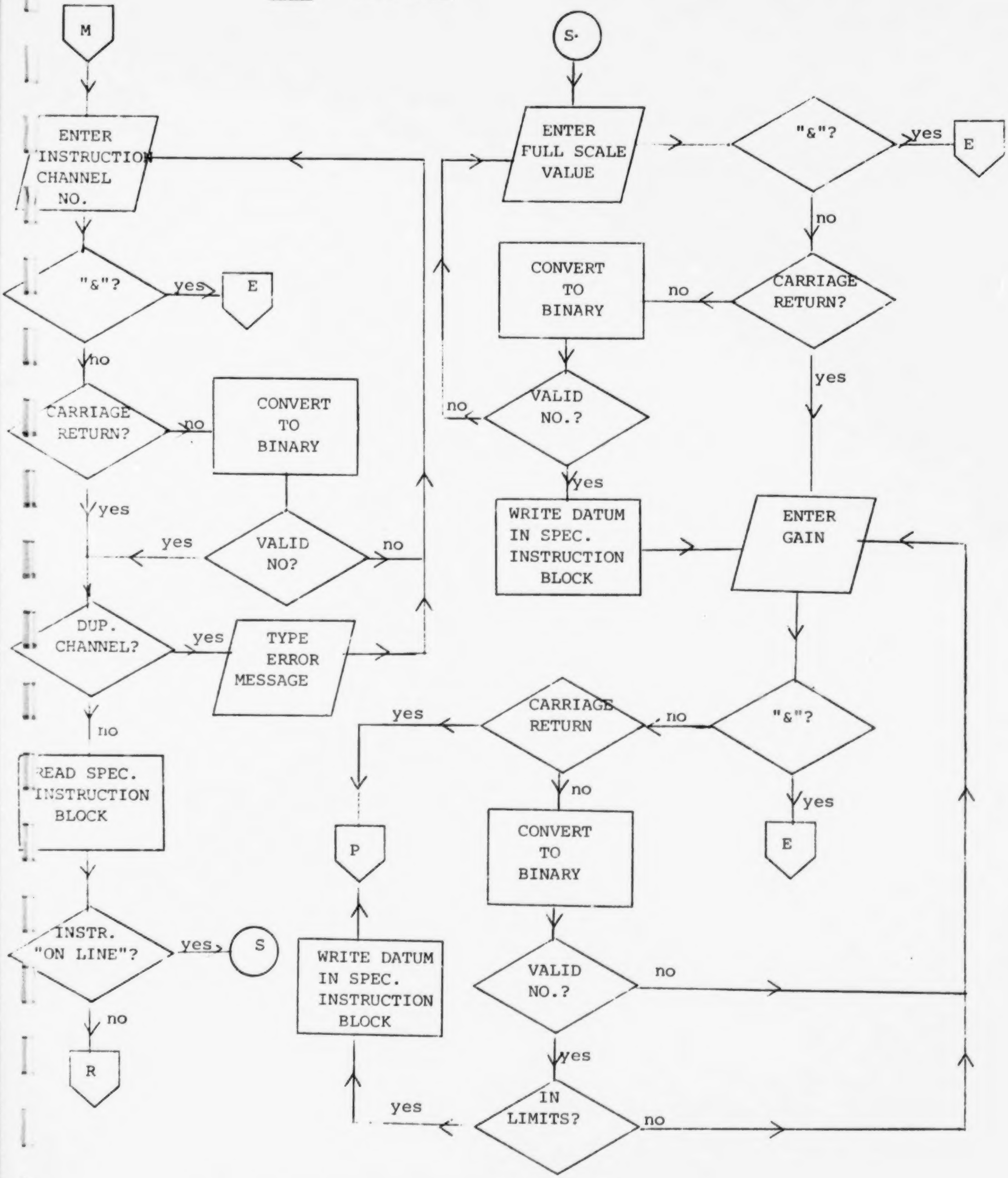
PSET (continued)


C
IN "MONR"?
no
TYPE ERROR MESSAGE
E
yes
READ OVERLAY
IS INSTR. ON LIST?
no
TYPE ERROR MESSAGE
F
yes
PERM. INSTRUCTION
no
M
yes
READ SPEC. INSTRUCTION BLOCK
INST. "ON LINE"?
no
R
TYPE "INST. OFF LINE" MESSAGE
F
yes
N
N
1st INSTRUCTION?
no
2nd OR 3rd INSTRUCTION ?
yes
TYPE "ILLEGAL INSTRUCTION" MESSAGE
F
no
O
yes
Q
ENTER %SS DEVIATION
"&"?
yes
E
no
CONVERT TO BINARY
VALID NO.?
no
Q
yes
WRITE DATA IN SPEC. INSTR. BLOCK
WRITE SPEC. INSTRUCTION BLOCK
P
F

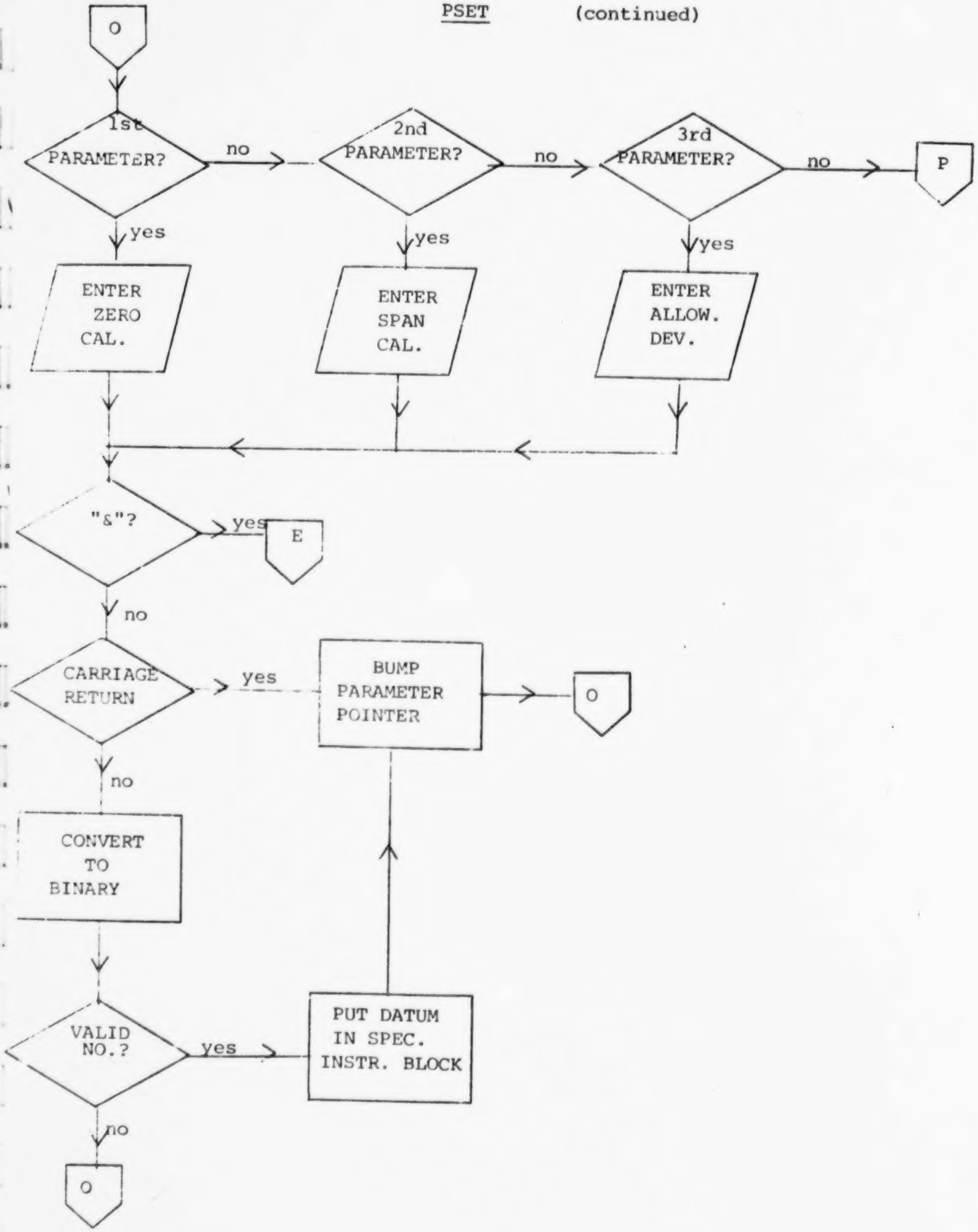
PSET (continued)


K
READ & TYPE CARD DATA
"&"?
yes
I
no
DOES NAME MATCH TABLE?
no
K
yes
READ SPEC. INSTRUCTION BLOCK
INST. "ON LINE" ?
no
TYPE "OFF LINE" MESSAGE
J
yes
CONVERT DATA TO BINARY
VALID NO.?
yes
no
L
PERM. INSTRUCTION?
yes
ENTER PERM. DATA
ENTER AUXIL. DATA
WRITE SPEC. INSTRUCTION BLOCK
INST. TABLE FULL?
yes
TYPE "TABLE FULL" MESSAGE
I
no
J

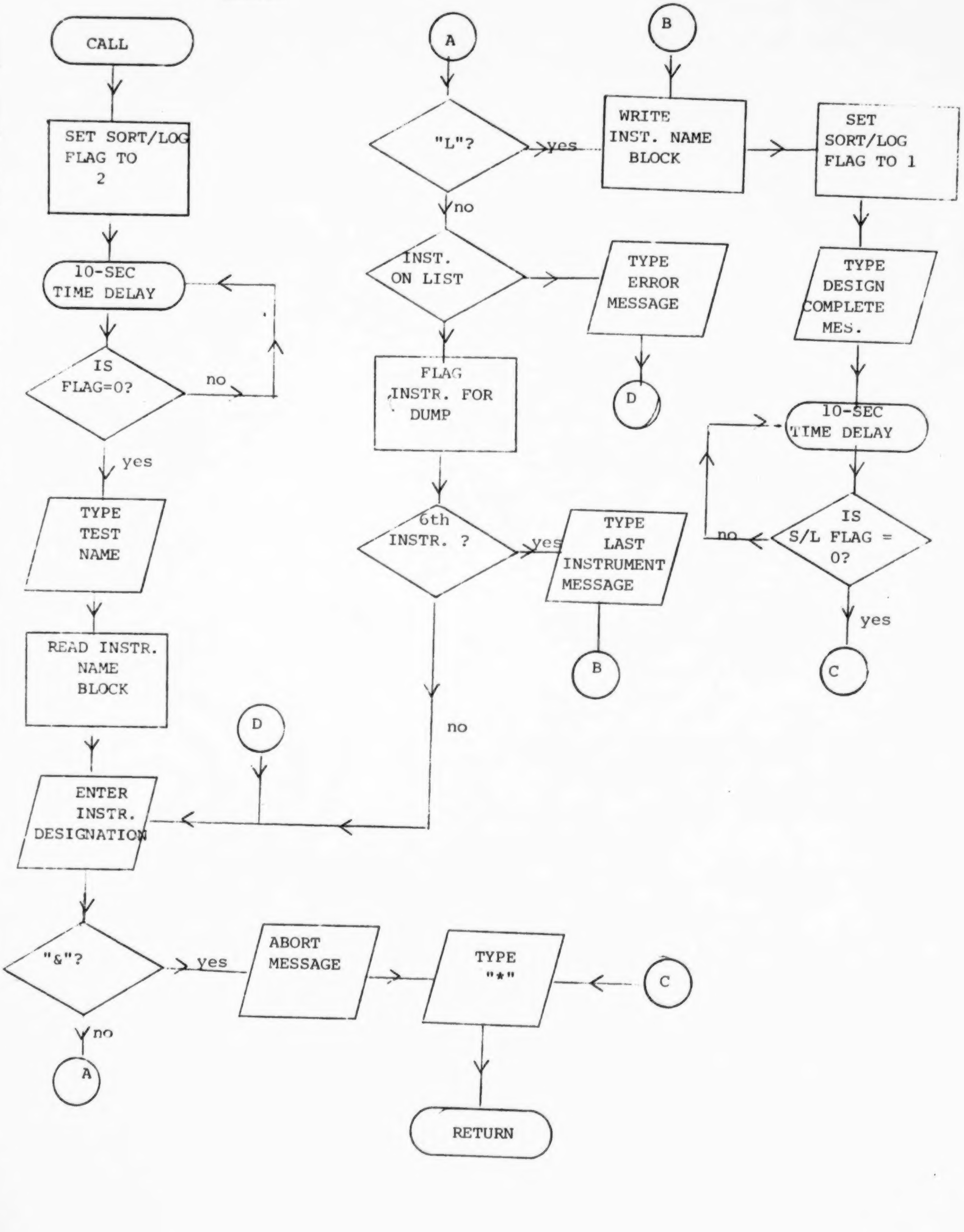
PSET (continued)


M
ENTER INSTRUCTION CHANNEL NO.
"&"?
yes
E
no
CARRIAGE RETURN?
no
CONVERT TO BINARY
yes
VALID NO?
yes
no
DUP. CHANNEL?
yes
TYPE ERROR MESSAGE
no
READ SPEC. INSTRUCTION BLOCK
INSTR. "ON LINE"?
yes
S
no
R
S
ENTER FULL SCALE VALUE
"&"?
yes
E
no
CARRIAGE RETURN?
no
CONVERT TO BINARY
VALID NO.?
no
yes
WRITE DATUM IN SPEC. INSTRUCTION BLOCK
yes
ENTER GAIN
"&"?
yes
E
no
CARRIAGE RETURN
yes
P
no
CONVERT TO BINARY
VALID NO.?
no
yes
IN LIMITS?
no
yes
WRITE DATUM IN SPEC. INSTRUCTION BLOCK

PSET (continued)

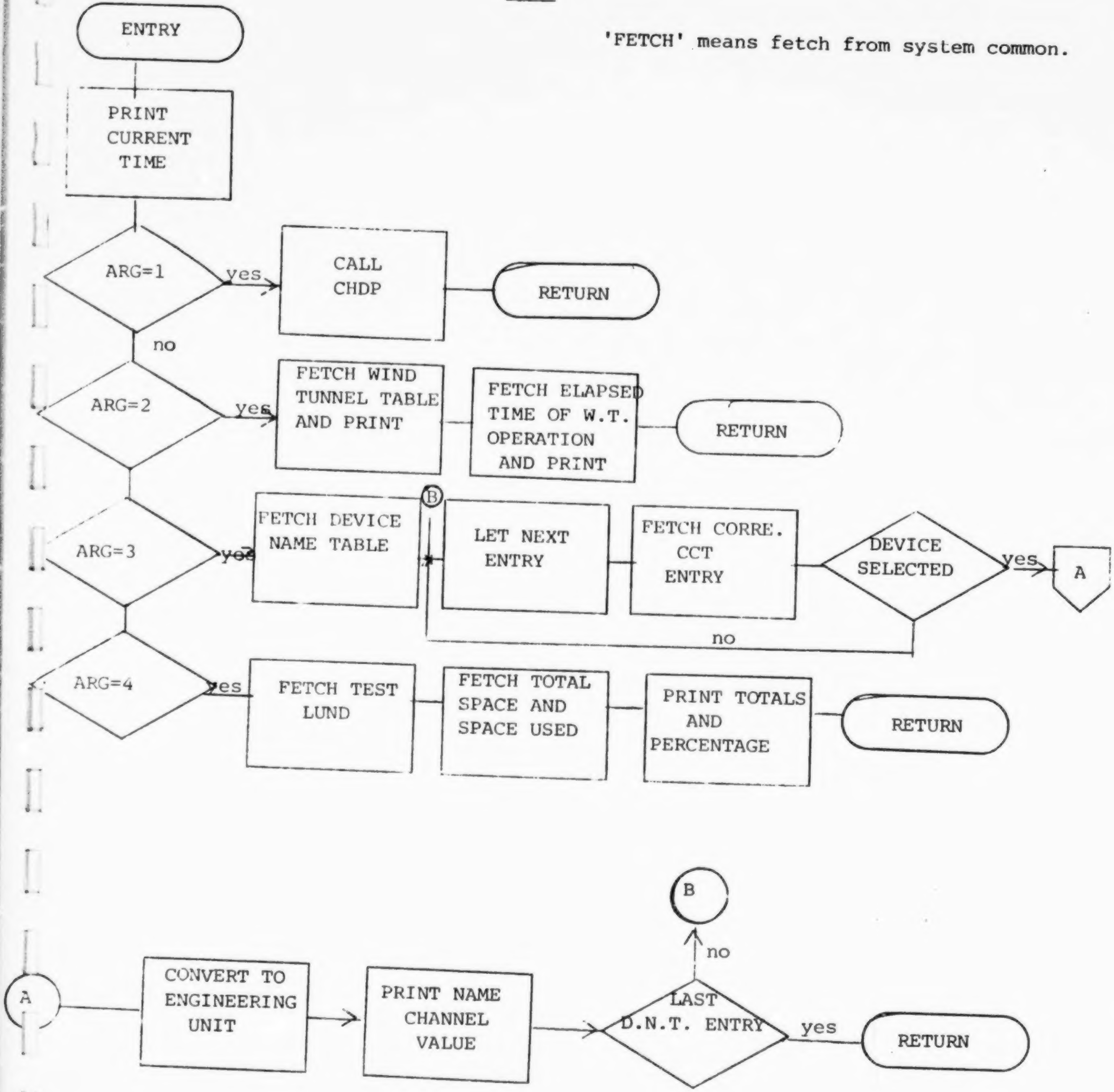

O
1st PARAMETER?
no
2nd PARAMETER?
no
3rd PARAMETER?
no
P
yes
ENTER ZERO CAL.
yes
ENTER SPAN CAL.
yes
ENTER ALLOW. DEV.
"&"?
yes
E
no
CARRIAGE RETURN
yes
BUMP PARAMETER POINTER
O
no
CONVERT TO BINARY
VALID NO.?
yes
PUT DATUM IN SPEC. INSTR. BLOCK
no
O

SORT C


CALL
SET SORT/LOG FLAG TO 2
10-SEC TIME DELAY
IS FLAG=0?
no
yes
TYPE TEST NAME
READ INSTR. NAME BLOCK
D
ENTER INSTR. DESIGNATION
"&"?
yes
no
A
ABORT MESSAGE
TYPE "*"
C
RETURN
A
"L"?
yes
no
INST. ON LIST
TYPE ERROR MESSAGE
D
FLAG INSTR. FOR DUMP
6th INSTR. ?
yes
no
TYPE LAST INSTRUMENT MESSAGE
B
B
WRITE INST. NAME BLOCK
SET SORT/LOG FLAG TO 1
TYPE DESIGN COMPLETE MES.
10-SEC TIME DELAY
IS S/L FLAG = 0?
no
yes
C

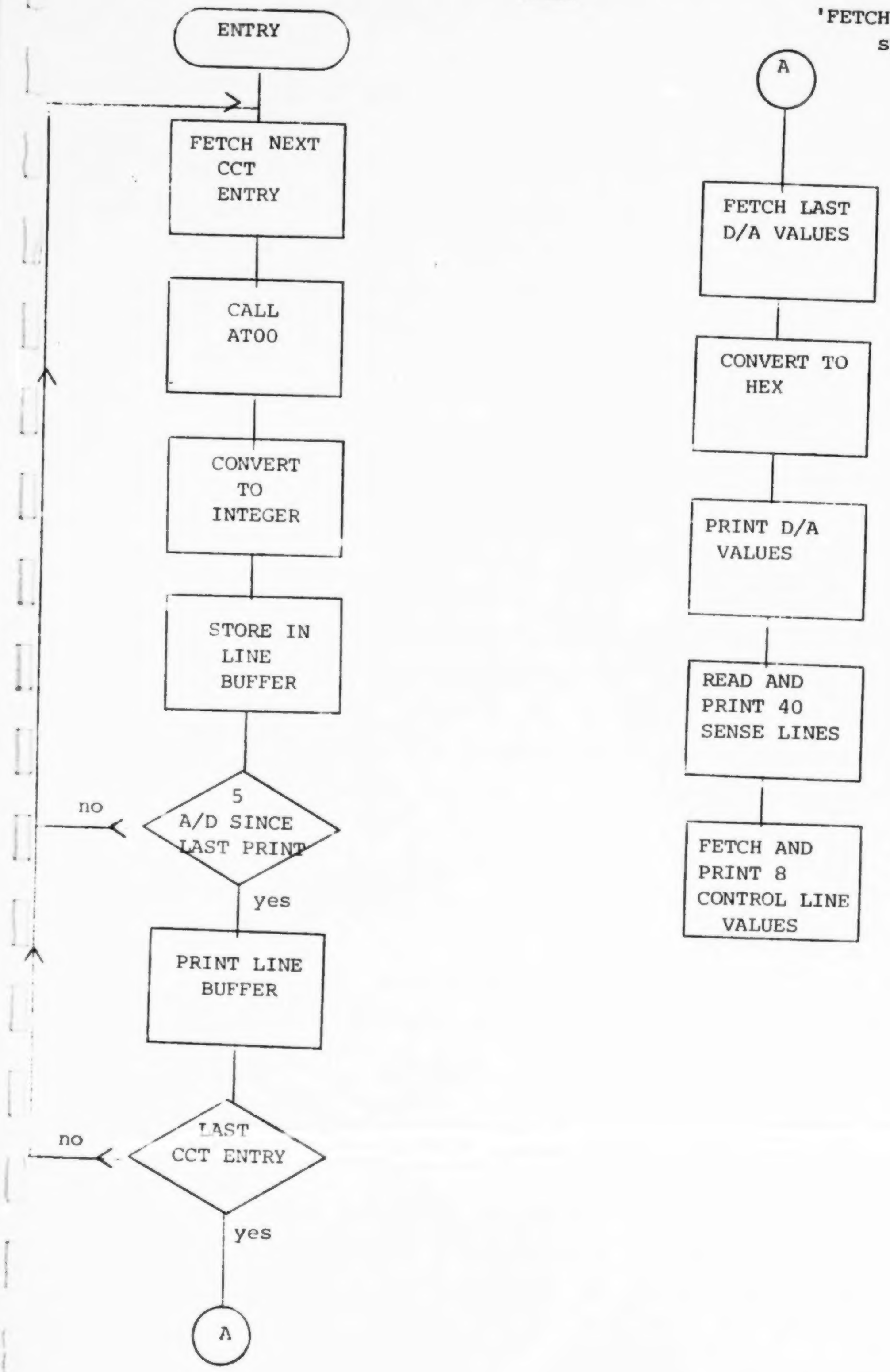
DUMP

'FETCH' means fetch from system common.


ENTRY
PRINT CURRENT TIME
ARG=1
yes
CALL CHDP
RETURN
no
ARG=2
yes
FETCH WIND TUNNEL TABLE AND PRINT
FETCH ELAPSED TIME OF W.T. OPERATION AND PRINT
RETURN
ARG=3
yes
FETCH DEVICE NAME TABLE
B
LET NEXT ENTRY
FETCH CORRE. CCT ENTRY
DEVICE SELECTED
yes
A
no
ARG=4
yes
FETCH TEST LUND
FETCH TOTAL SPACE AND SPACE USED
PRINT TOTALS AND PERCENTAGE
RETURN
B
no
A
CONVERT TO ENGINEERING UNIT
PRINT NAME CHANNEL VALUE
LAST D.N.T. ENTRY
yes
RETURN

CHDP

'FETCH' means fetch from system common.


ENTRY
FETCH NEXT CCT ENTRY
CALL AT00
CONVERT TO INTEGER
STORE IN LINE BUFFER
5 A/D SINCE LAST PRINT
no
yes
PRINT LINE BUFFER
LAST CCT ENTRY
no
yes
A
A
FETCH LAST D/A VALUES
CONVERT TO HEX
PRINT D/A VALUES
READ AND PRINT 40 SENSE LINES
FETCH AND PRINT 8 CONTROL LINE VALUES

7.6 WIND TUNNEL DRIVER (ID=28)

This task calculates the gas velocity and displays this velocity on a 10-volt D/A output. It also prints a message on the line printer when the velocity is less than 10 ft/sec and the velocity auto/manual switch is in the "auto" position. When the system is in the "operate" mode and appropriate auto/manual switches are in "auto" positions this task will control the velocity, temperature and humidity of the tunnel according to values entered in the "Wind Tunnel Driver Table".

7.6.1 COMPOSITION OF WIND TUNNEL DRIVER

The driver consists of a main routine and subroutines RSTIO, RTADP, VDRVE, TDRVE, HDRVE, CONCL, ATOD, DTOA and CDAT. The first four subroutines calculate velocity from temperature and delta pressure, control tunnel velocity, controls tunnel temperature and controls tunnel humidity, respectively. The remaining subroutines are discussed in the section of commonly used subroutines.

7.6.2 SUBROUTINE RSTIO

This subroutine sets all contact closures to zero and the D/A outputs to a minimum value. It is called once when task 28 is loaded.

7.6.3 SUBROUTINE RTADP

This subroutine reads the temperature and delta pressure A/D inputs, calculates the temperature and gas velocity, displays velocity on D/A and stores temperature and velocity in common data task.

7.6.4 SUBROUTINE VDRVE

This subroutine controls the wind tunnel velocity when two conditions are met; the system is in the "operate" mode and the velocity auto/manual switch is in the "auto"position. Velocity is determined by a value in the "Wind Tunnel Driver Table" and a velocity feed-back value. During the dirst minute of any new cycle, the output velocity is defined by only the table value. After that time, the output velocity is determined by the formula:

Velocity = (Measured velocity-table velocity)/2+last output velocity

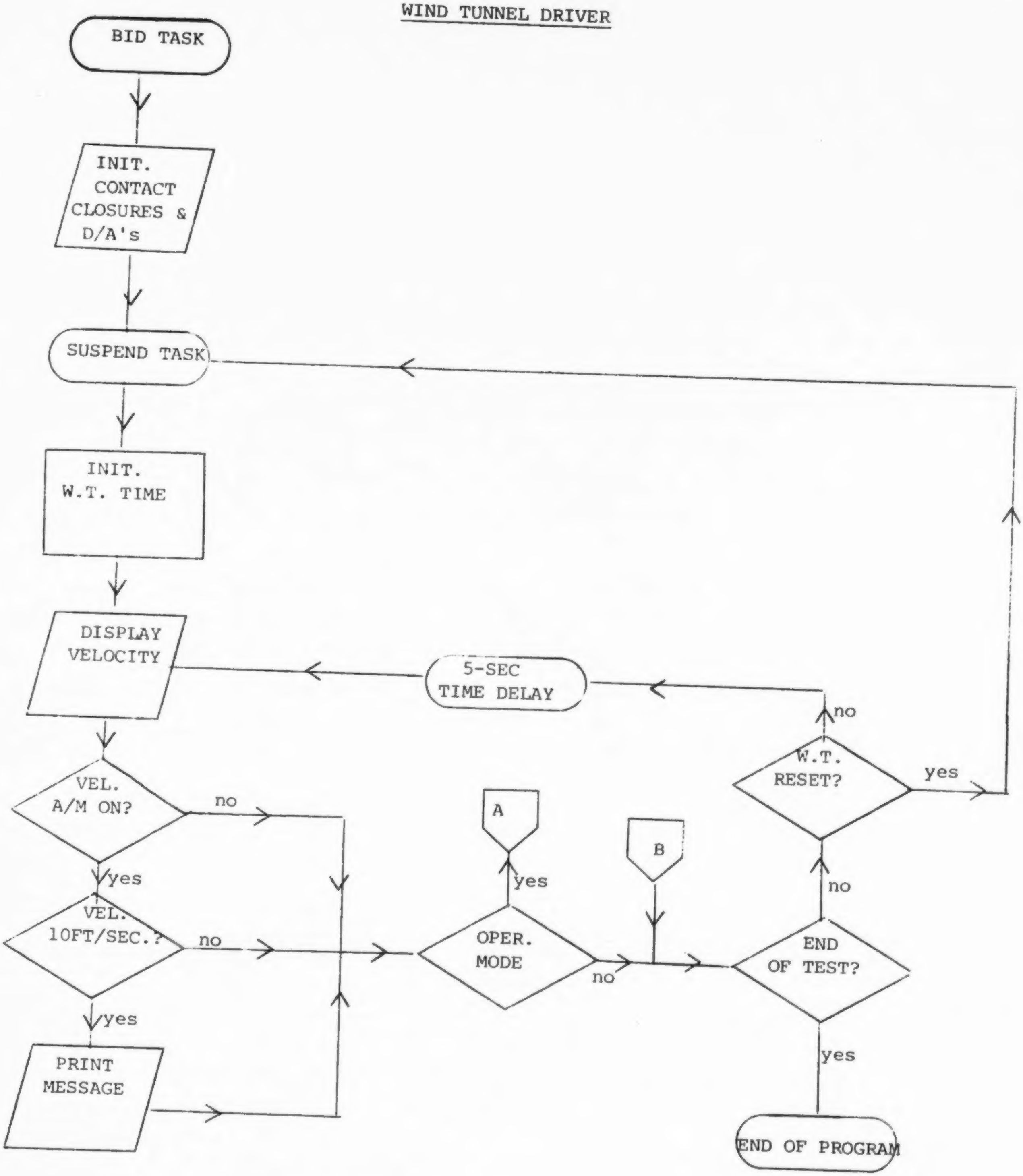
7.6.5 SUBROUTINE TDRVE

This subroutine controls the wind tunnel temperature thru a table value transmitted via a D/A converter to a set-point controller. Like VDRVE, this subroutine is only active when the system is in the "operate" mode and the temperature auto/manual switch is in the "auto" position.

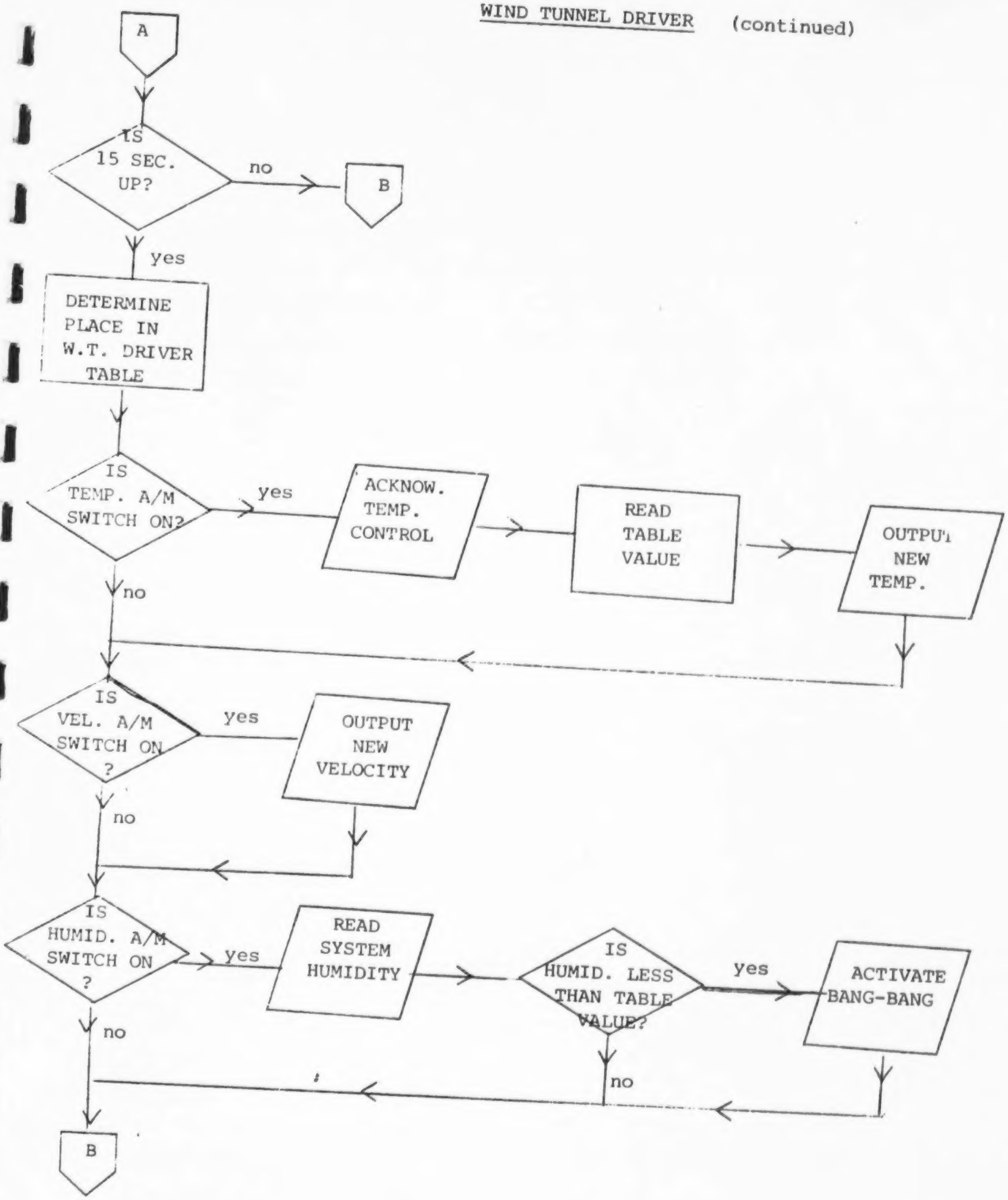
7.6.6 SUBROUTINE HDRVE

This subroutine controls the wind tunnel humidity by activating a bang-bang steam injector. This contact closure is activated only when the system is in the "operate" mode, the humidity auto/manual switch is in the "auto"position and the measured humidity is less than the humidity designated in the "Wind Tunnel Driver Table."

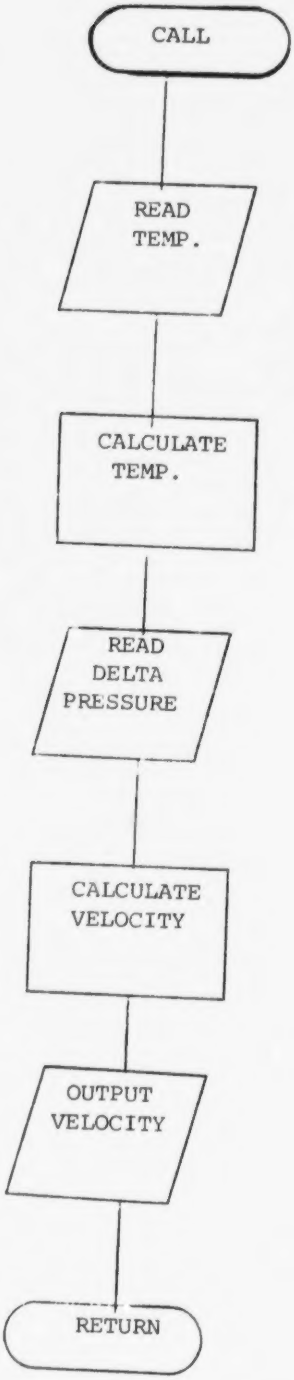
WIND TUNNEL DRIVER


BID TASK
INIT.
CONTACT
CLOSURES &
D/A's
SUSPEND TASK
INIT.
W.T. TIME
DISPLAY
VELOCITY
5-SEC
TIME DELAY
no
W.T.
RESET?
yes
VEL.
A/M ON?
no
A
B
yes
yes
VEL.
10FT/SEC.?
no
OPER.
MODE
no
END
OF TEST?
no
yes
yes
PRINT
MESSAGE
END OF PROGRAM

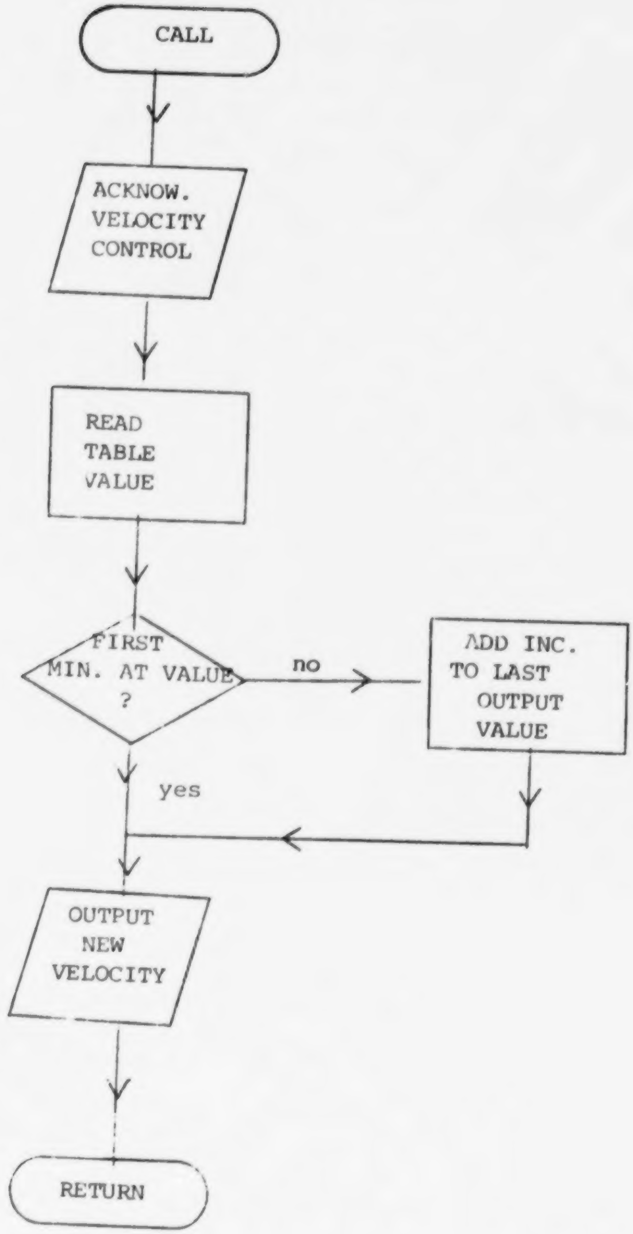
WIND TUNNEL DRIVER (continued)


A
IS 15 SEC. UP?
no
B
yes
DETERMINE PLACE IN W.T. DRIVER TABLE
IS TEMP. A/M SWITCH ON?
yes
ACKNOW. TEMP. CONTROL
READ TABLE VALUE
OUTPUT NEW TEMP.
no
IS VEL. A/M SWITCH ON ?
yes
OUTPUT NEW VELOCITY
no
IS HUMID. A/M SWITCH ON ?
yes
READ SYSTEM HUMIDITY
IS HUMID. LESS THAN TABLE VALUE?
yes
ACTIVATE BANG-BANG
no
no
B

RTADP


CALL
READ TEMP.
CALCULATE TEMP.
READ DELTA PRESSURE
CALCULATE VELOCITY
OUTPUT VELOCITY
RETURN

VDRVE


CALL
ACKNOW. VELOCITY CONTROL
READ TABLE VALUE
FIRST MIN. AT VALUE ?
no
ADD INC. TO LAST OUTPUT VALUE
yes
OUTPUT NEW VELOCITY
RETURN

7.7 FAULT CHECKING TASK (ID=27)

The fault check task consists of a main routine (FLTCK) and three subroutines (WRFLT, CONCL and CDAT). The main routine surveys contact closures 1, a and 6 thru 23 and selects an appropriate message to be printed on the line printer if any of these closures is on. Prior to printing sixteen (16) of the eighteen (18) messages the fault override array is examined and all of the allowed messages are printed by WRFLT. The remaining two messages will always be printed unless the corresponding contact closures are "off".

7.7.1 TIME DELAY - FAULT CHECK TASK BIDDING TASK

This task (TASK 21) exists only to "unsuspend" TASK 27 and consists of a main routine (TDFLC) and subroutine (CDAT). A cycle of this task consists of a 10-second time delay, unsuspend TASK 27, check for end of test (or reset) and another time delay.

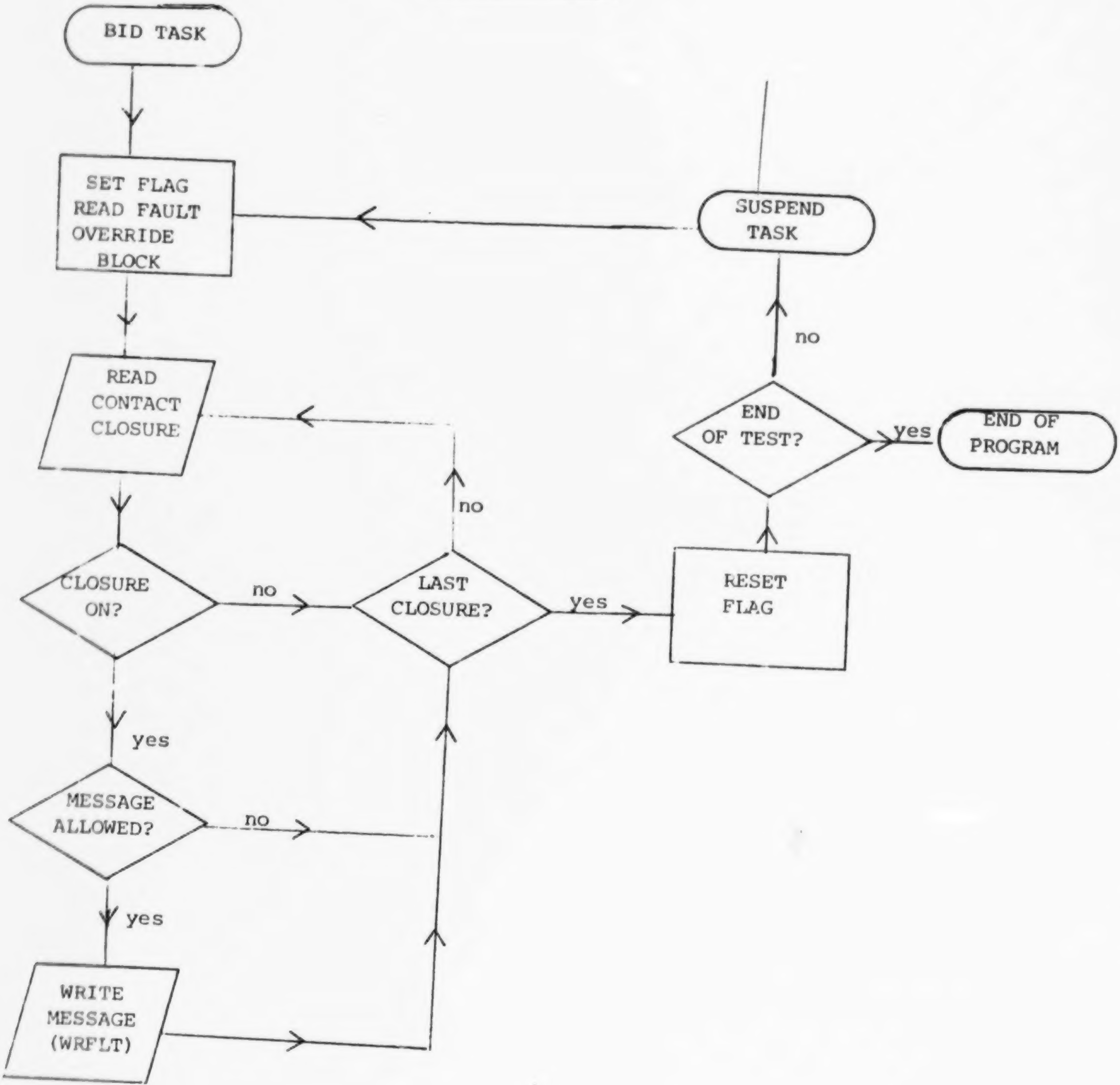
7.8 SORT/LOG TASK (ID=35)

The SORT/LOG task performs two primary system functions:

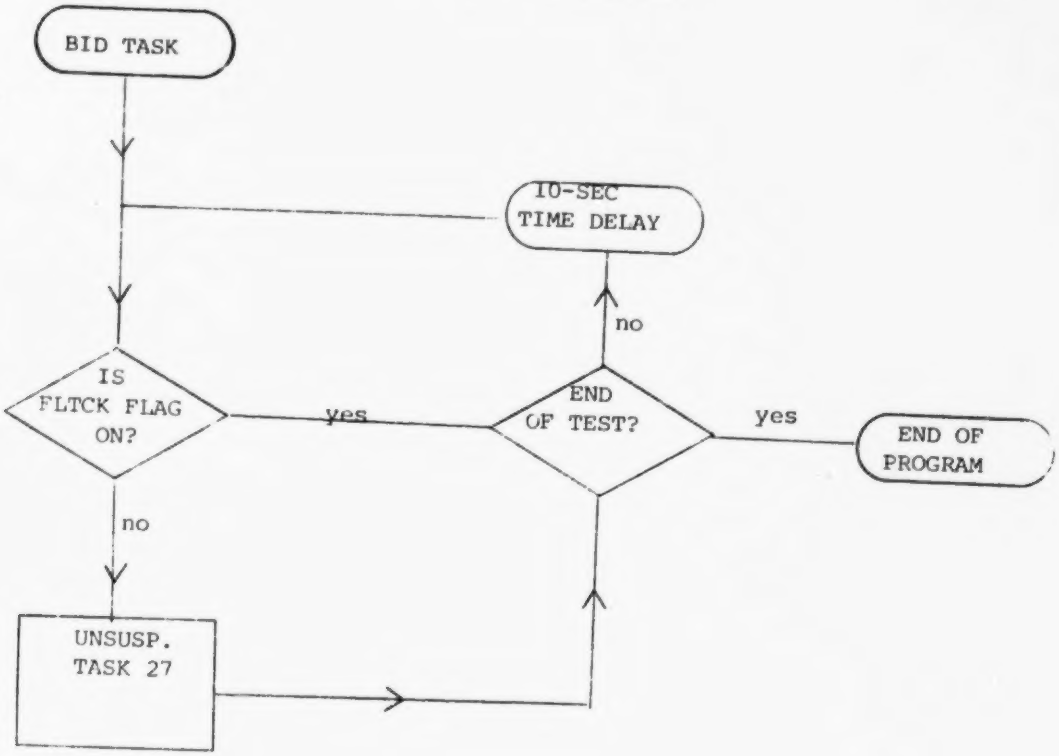
1. Periodically logs A/D input from defined instruments and important wind tunnel parameter values.
2. Provides a printed output of entire log file.

Logging of data during a test occurs on a predefined test file. The test file LUNO is stored at pointer 70 of System Common. SORT/LOG is the only SSDCS module which reads or modifies the test file.

TASK 27 - FLTCK


BID TASK
SET FLAG READ FAULT OVERRIDE BLOCK
READ CONTACT CLOSURE
CLOSURE ON?
no
yes
MESSAGE ALLOWED?
no
yes
WRITE MESSAGE (WRFLT)
LAST CLOSURE?
no
yes
RESET FLAG
END OF TEST?
no
yes
END OF PROGRAM
SUSPEND TASK

TASK 21 - TDFLC


BID TASK
10-SEC TIME DELAY
no
IS FLTCK FLAG ON?
yes
END OF TEST?
yes
END OF PROGRAM
no
UNSUSP. TASK 27

The test file is a 128 sector indexed direct access file. During a test the file is structured as follows:

Record	1	12	13	120	128
	Test Specifications Header		Data Records	PAM/D Index Blocks	

Each logical record written to the test file corresponds to a disk sector (32 words), hence there is no effective distinction between logical records and physical sectors.

The header information at the beginning of the file is inclusive enough to completely reconstruct the instrumentation configuration at the time of the test. Hence, a test file may be kept over any length of time and dumped from a non-configured system.

All SORT/LOG actions are initiated from the Operator Communication task. OP-COM and SORT/LOG communicate through pointer 3 of System Common. OP-COM indicates necessary commands to SORT/LOG by placing special operation codes in this location. SORT/LOG, which is in a time delay loop, periodically checks reference location 3 for commands. When SORT/LOG completes a requested operation, it resets reference 3 to zero.

SORT/LOG consists of 5 major portions - a main routine and four overlays. The main program has control whenever actual logging is not in progress.

The functions of the four overlays is summarized below:

1. ONTF (Open New Test File) writes the header block to the test file.

2. LOGG (Logging Overlay) is responsible for recording of actual data during a test.

3. OOTF (Open Old Test File) reads back the header block of a test file and reconstructs the environment at the time of the test.

4. SORT (Sort Logged Data) provides a neatly formatted printer listing of data logged during a test.

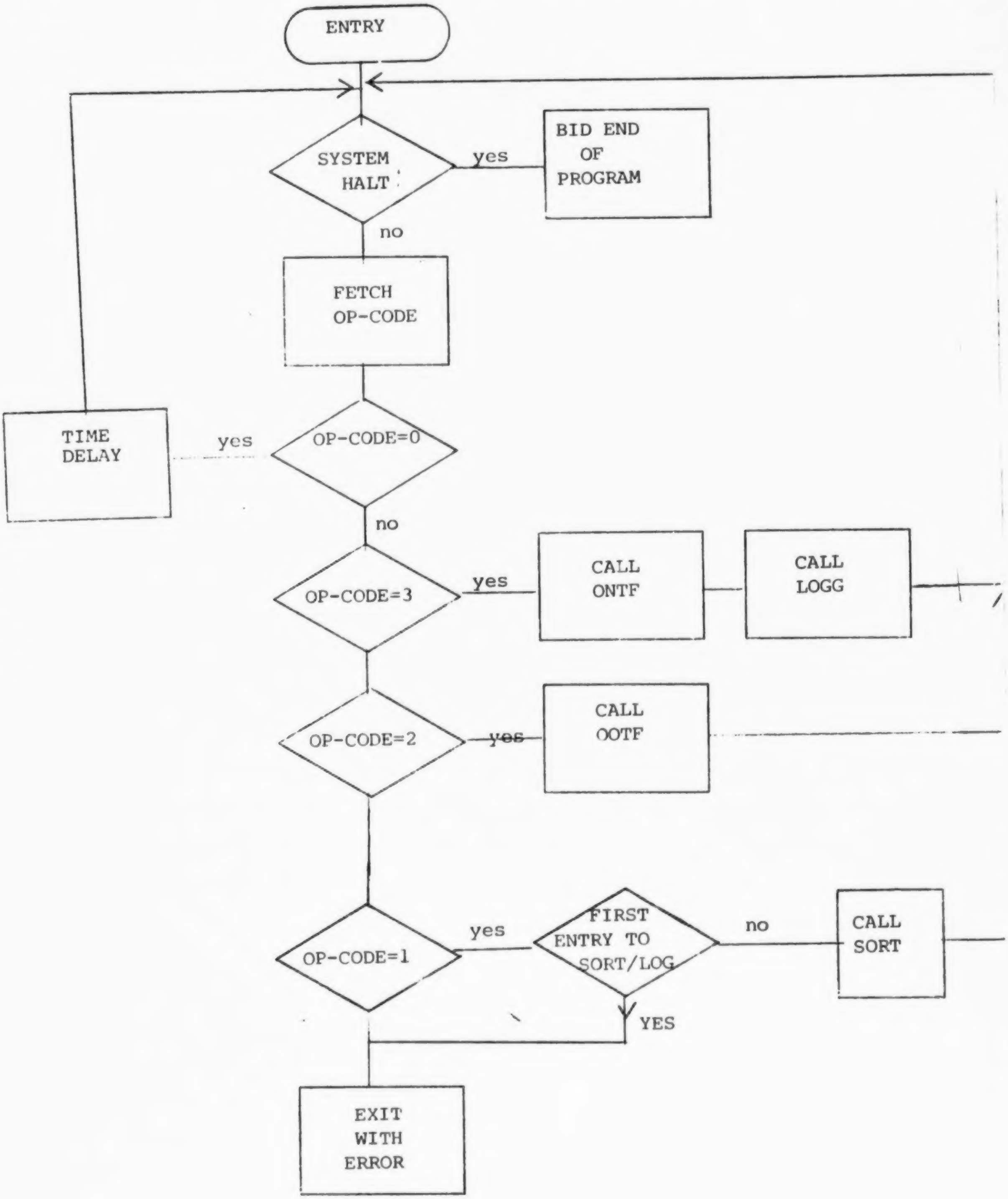
Only two operator commands affect SORT/LOG. On acceptance of the 'OPER' command OP-COM initiates logging by storing the value 3 in the SORT/LOG communication word. SORT/LOG, when detecting this code, loads and executes ONTF. Upon completion of opening the test file, LOGG is loaded and begins execution. LOGG remains in execution till terminated by OP-COM on entry of the "SORT" command.

OP-COM indicates acceptance of the "SORT" command by placing a 2 in the SORT/LOGG communication word. SORT/LOGG terminates logging and proceeds to load and execute OOTF. OOTF simply reads the header, resets the operation code to zero and returns to time delay. OP-COM then requests an instrument list from the operator. As the operator inputs this list, OP-COM modifies the appropriate channel numbers in Device Name Table to indicate selection. After the list has been specified, OP-COM requests the SORT function by storing a 1 in the SORT/LOGG communication word. SORT/LOGG then picks up the flags and prints the data, and resets all flags.

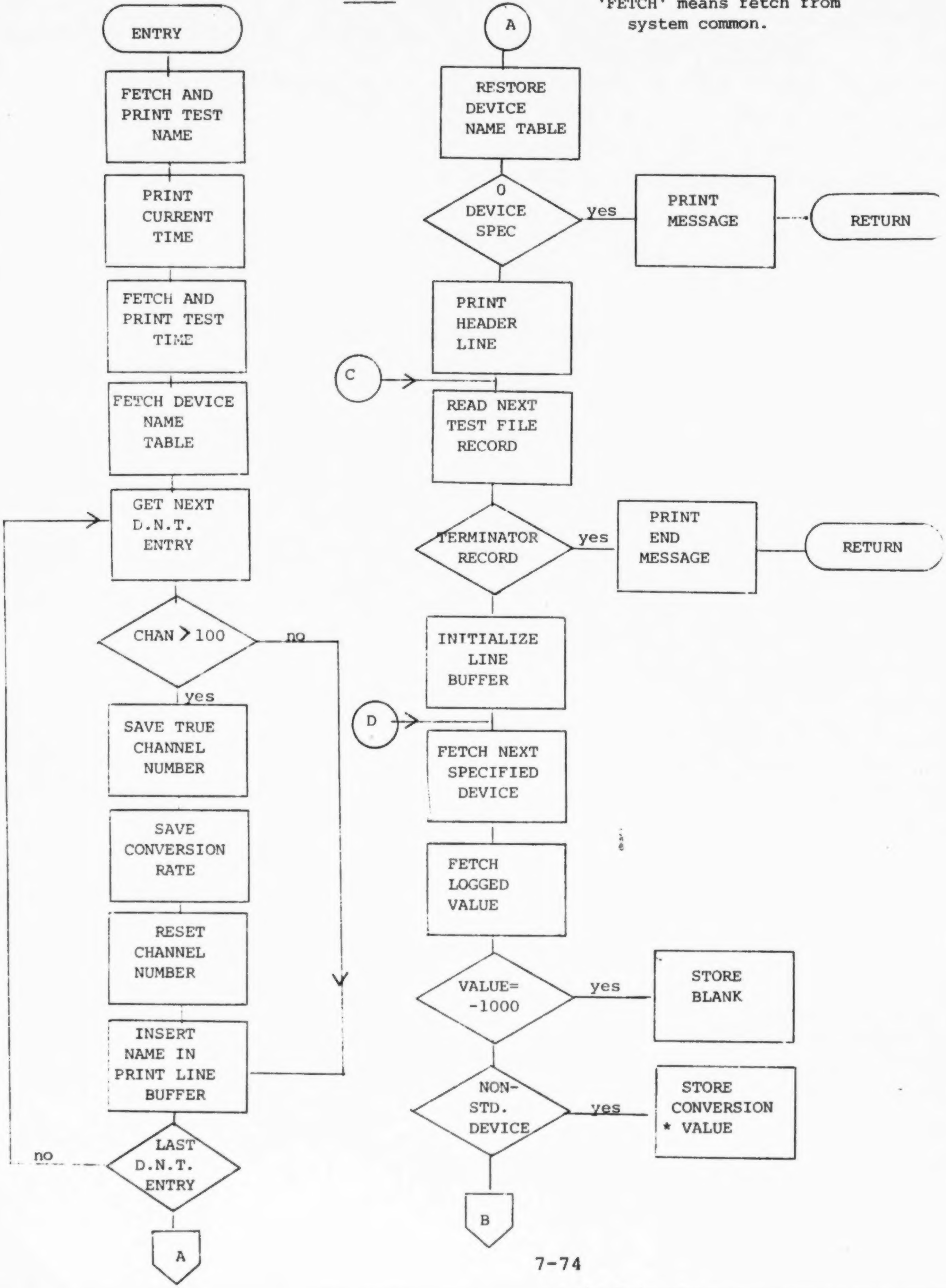
Each overlay which writes to the test file uses a specially written PCL callable routine RITE which writes one sector to the test file. Reading from the test file is handled 1 sector at a time by routine REED.

MAIN TASK SORT/LOG

'FETCH' means fetch from system common.

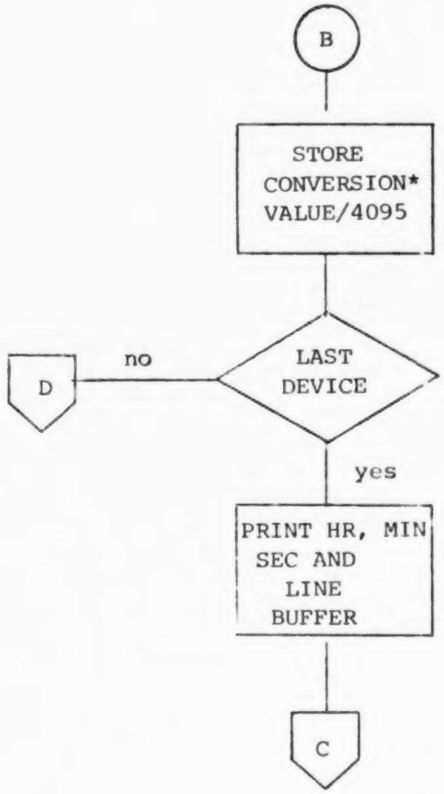

ENTRY
SYSTEM HALT
yes
BID END OF PROGRAM
no
FETCH OP-CODE
TIME DELAY
yes
OP-CODE=0
no
OP-CODE=3
yes
CALL ONTF
CALL LOGG
OP-CODE=2
yes
CALL OOTF
OP-CODE=1
yes
FIRST ENTRY TO SORT/LOG
no
CALL SORT
YES
EXIT WITH ERROR

SORT


ENTRY
FETCH AND PRINT TEST NAME
PRINT CURRENT TIME
FETCH AND PRINT TEST TIME
FETCH DEVICE NAME TABLE
GET NEXT D.N.T. ENTRY
CHAN > 100
no
yes
SAVE TRUE CHANNEL NUMBER
SAVE CONVERSION RATE
RESET CHANNEL NUMBER
INSERT NAME IN PRINT LINE BUFFER
LAST D.N.T. ENTRY
no
A
A
RESTORE DEVICE NAME TABLE
0 DEVICE SPEC
yes
PRINT MESSAGE
RETURN
PRINT HEADER LINE
C
READ NEXT TEST FILE RECORD
TERMINATOR RECORD
yes
PRINT END MESSAGE
RETURN
INITIALIZE LINE BUFFER
D
FETCH NEXT SPECIFIED DEVICE
FETCH LOGGED VALUE
VALUE= -1000
yes
STORE BLANK
NON-STD. DEVICE
yes
STORE CONVERSION * VALUE
B

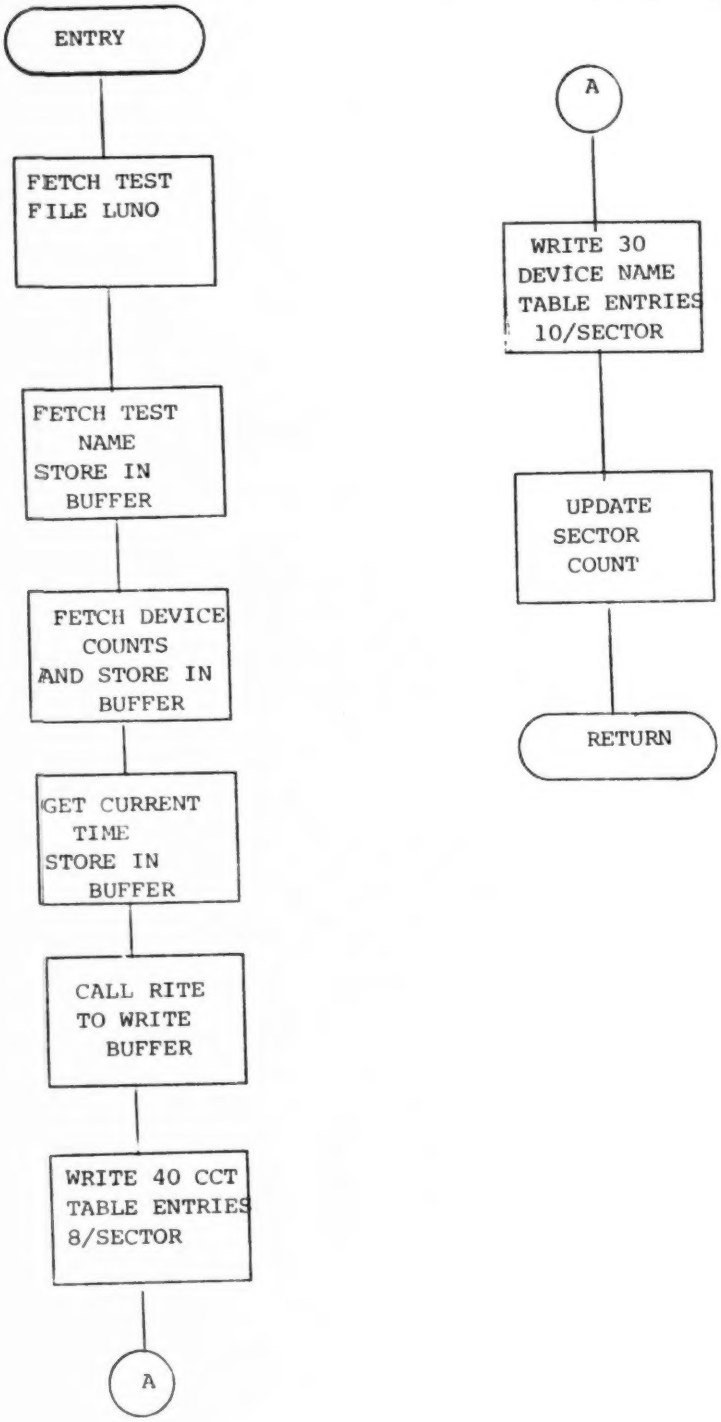
'FETCH' means fetch from system common.

SORT (continued)


B
STORE CONVERSION* VALUE/4095
LAST DEVICE
no
D
yes
PRINT HR, MIN SEC AND LINE BUFFER
C

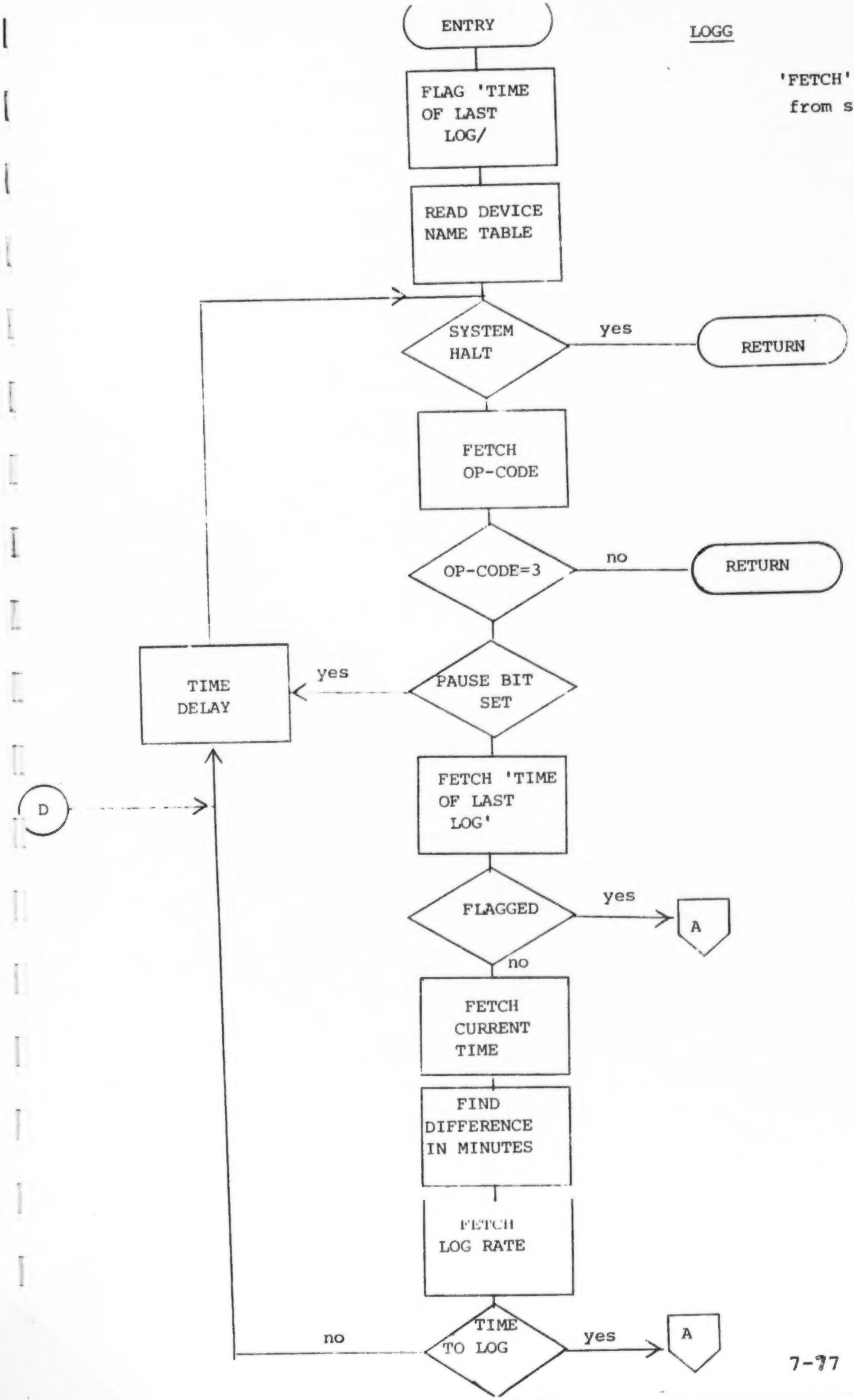
ONTF

'FETCH' means fetch from system common.

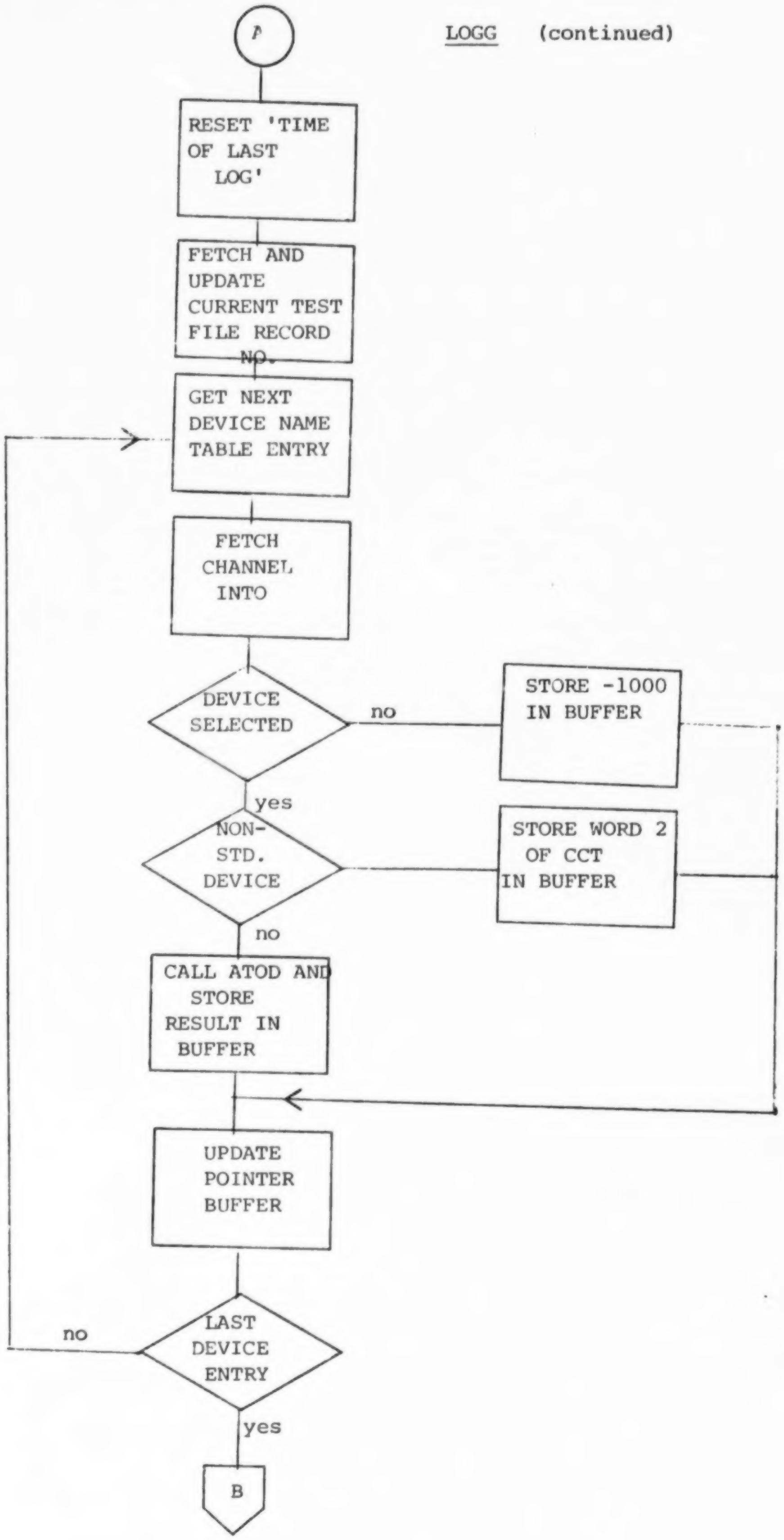

ENTRY
FETCH TEST FILE LUNO
FETCH TEST NAME STORE IN BUFFER
FETCH DEVICE COUNTS AND STORE IN BUFFER
GET CURRENT TIME STORE IN BUFFER
CALL RITE TO WRITE BUFFER
WRITE 40 CCT TABLE ENTRIES 8/SECTOR
A
A
WRITE 30 DEVICE NAME TABLE ENTRIES 10/SECTOR
UPDATE SECTOR COUNT
RETURN

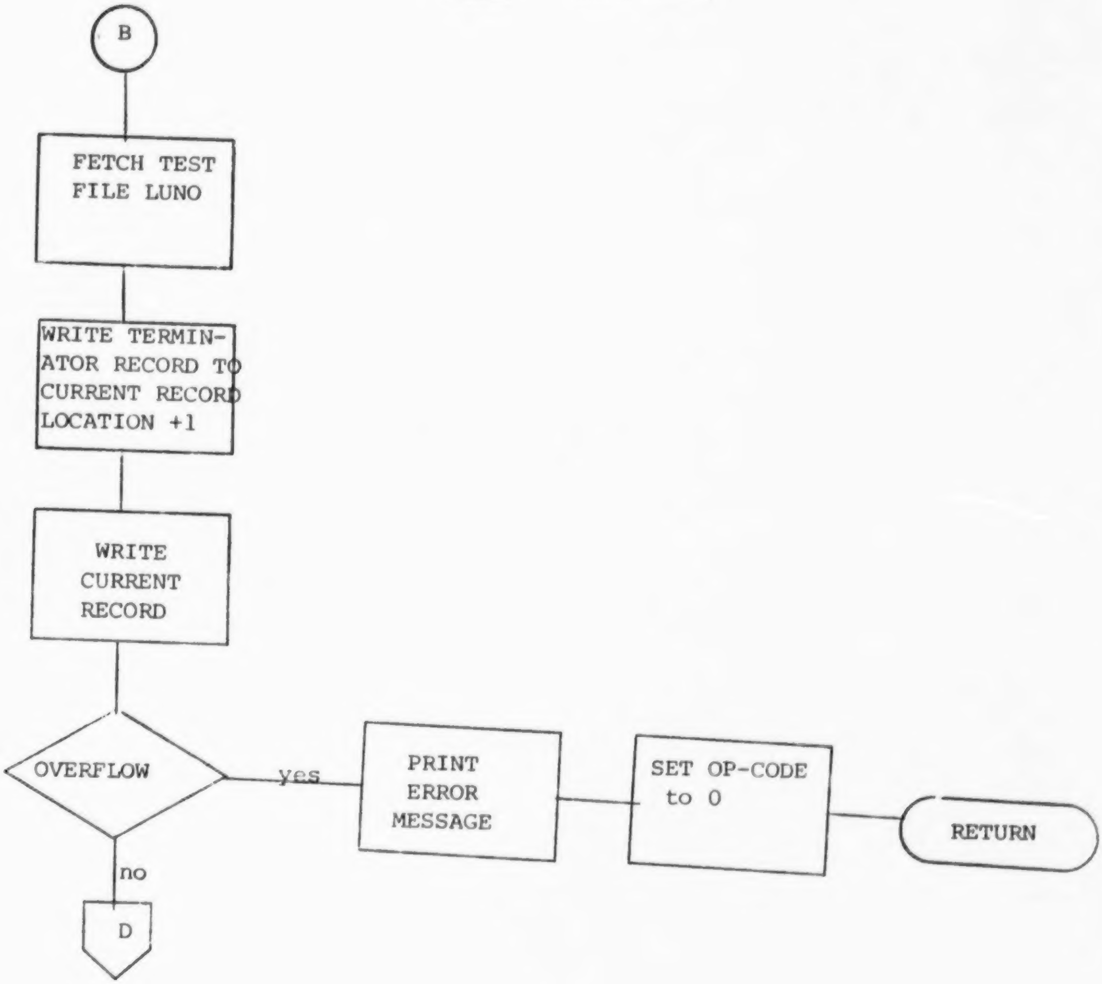
LOGG

'FETCH' means fetch from system common.


ENTRY
FLAG 'TIME OF LAST LOG/
READ DEVICE NAME TABLE
SYSTEM HALT
yes
RETURN
FETCH OP-CODE
OP-CODE=3
no
RETURN
PAUSE BIT SET
yes
TIME DELAY
D
FETCH 'TIME OF LAST LOG'
FLAGGED
yes
A
no
FETCH CURRENT TIME
FIND DIFFERENCE IN MINUTES
FETCH LOG RATE
TIME TO LOG
no
yes
A

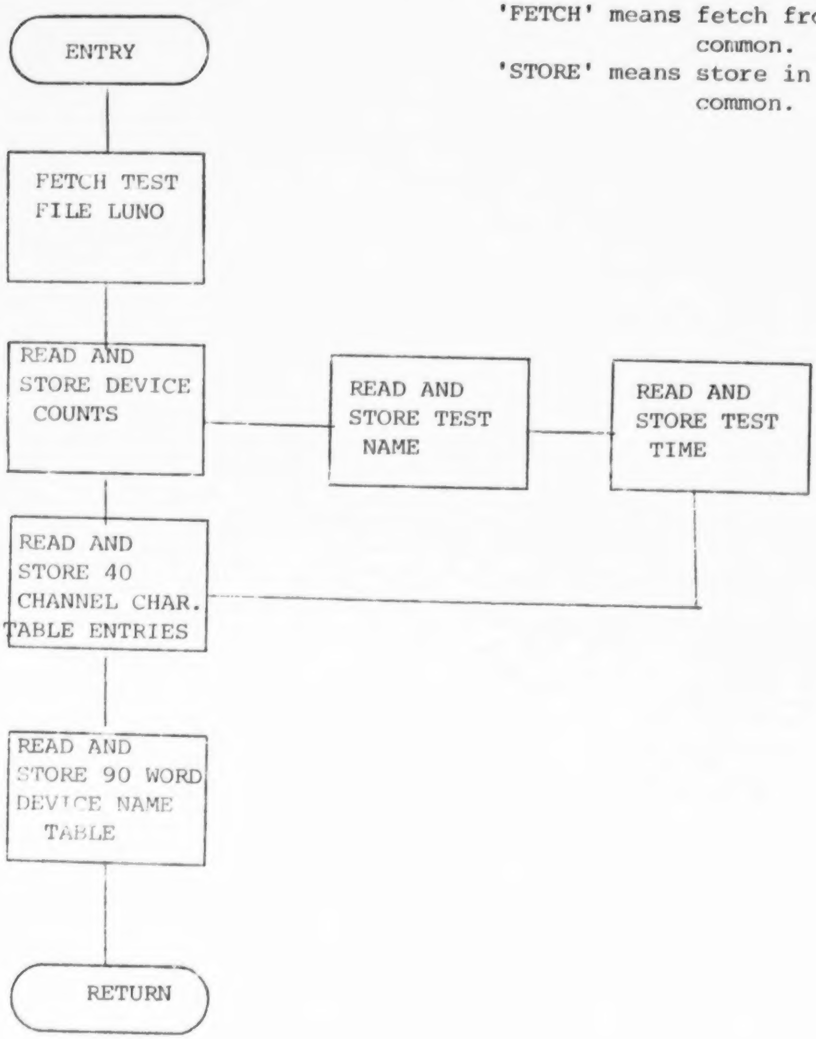
LOGG (continued)


A
RESET 'TIME OF LAST LOG'
FETCH AND UPDATE CURRENT TEST FILE RECORD NO.
GET NEXT DEVICE NAME TABLE ENTRY
FETCH CHANNEL INTO
DEVICE SELECTED
no
STORE -1000 IN BUFFER
yes
NON-STD. DEVICE
STORE WORD 2 OF CCT IN BUFFER
no
CALL ATOD AND STORE RESULT IN BUFFER
UPDATE POINTER BUFFER
LAST DEVICE ENTRY
no
yes
B


B
FETCH TEST FILE LUNO
WRITE TERMINATOR RECORD TO CURRENT RECORD LOCATION +1
WRITE CURRENT RECORD
OVERFLOW
yes
PRINT ERROR MESSAGE
SET OP-CODE to 0
RETURN
no
D

OOTF

'FETCH' means fetch from system common.
'STORE' means store in system common.


ENTRY
FETCH TEST FILE LUNO
READ AND STORE DEVICE COUNTS
READ AND STORE TEST NAME
READ AND STORE TEST TIME
READ AND STORE 40 CHANNEL CHAR. TABLE ENTRIES
READ AND STORE 90 WORD DEVICE NAME TABLE
RETURN

CHAPTER 8

8.0 CONCLUSIONS AND RECOMMENDATIONS

The system was installed at EPA on 17 August 1973. Since the wind tunnel or source simulator was not completed or fully operational at that time, a complete integrated checkout was not possible. Communications since the delivery have indicated that the integration of the system is now completed and that all functions are being performed in a very satisfactory manner.

Six months of working and programming experience with the TI 960A/PAM-D system suggests several hardware and software modifications.

A. STA recommends the purchase and implementation of the arithmetic unit option for two reasons:

1. There is extensive use of floating point operations in the system delivered by STA. An overall improvement in system response time could be seen if this were added and some software timing loops modified.

2. PCLA could be implemented if the A/O board were present. PCLA is an improved PCL which is not only more powerful, but also more efficient. A lot of the work now done in assembly language could be done in PCLA with marginal increase in time and space utilization but sizable increase in flexibility and readability.

B. STA further recommends adding facilities for storage of relocatable object modules. Currently, such code may be saved only on the disk which is a highly volatile form of storage. A high speed paper tape reader/punch or an additional disc unit would serve fine.

With this device, the user will be able to generate new PAM/D systems as well as being much more secure from disk crashes. For example, one disk pack can be copied to another pack. This capability can significantly cut the recovery time from a system crash.

C. Addition of a second console terminal, suggest the Texas Instruments ASR733 with tape cassettes to separate OPCOM functions from system functions.

D. Reconfigure fault check to use interrupt drive rather than time delay polling.

E. Recommend addition of external memory to handle control loops for SO_2, NO_x and particulate.

F. The original field data system task as described in Phase I can be handled easily by the new TI 960A packaged cassette system with a timer and A/D added.